# 2011 RESEARCH REVIEW

# USDA-ARS

# SOFT WHEAT QUALITY LABORATORY

**2011 Annual Report**
**United States Department of Agriculture**
**Agricultural Research Service**
**Soft Wheat Quality Laboratory**
**1680 Madison Avenue**
**Wooster, OH 44691**

USDA Soft Wheat Quality Laboratory Website


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*ARS Vision and Mission*

*The ARS vision is to lead America towards a better future through agricultural research and information.*

*ARS conducts research to develop and transfer solutions to agricultural problems of high national priority and provide information access and dissemination to:*

- *ensure high-quality, safe food, and other agricultural products*
- *assess the nutritional needs of Americans*
- *sustain a competitive agricultural economy*
- *enhance the natural resource base and the environment*
- *provide economic opportunities for rural citizens, communities, and society as a whole.*

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# Soft Wheat Quality Laboratory (SWQL) Briefing Paper

UNITED STATES DEPARTMENT OF AGRICULTURE
AGRICULTURAL RESEARCH SERVICE
1680 Madison Ave., Wooster, Ohio

**MISSION**

- Contribute to global food security by enabling the development of new high-yielding cultivars with end-use quality suitable for commercial food production in the soft wheat milling and baking industries and the export trade. The SWQL has sole responsibility for this within the USDA for the eastern United States (U.S.).
- Address global climate change by reducing energy used to produce food through 1) selecting cultivars with improved milling efficiency 2) developing testing methods to assist in the purchasing of grain to match demands for high-efficiency milling and baking operations, and 3) reducing food loss due to flour shipments that do not meet specifications upon delivery at factories.
- Improve human nutrition, in collaboration eastern US wheat breeding programs, through identifying and deploying genes for greater food quality and nutrition.

**BACKGROUND**

Wheat is the world's largest crop used for direct human consumption. Approximately half of the wheat in the U.S. is milled in the eastern region served by the USDA-ARS Soft Wheat Quality Laboratory (SWQL), Wooster, OH. Since the 1930's, the SWQL has conducted genetic studies of wheat quality through long established coordinated research with 14 state land-grant universities in the eastern U.S. It is one of the few laboratories in the world that that develops methods for testing quality of soft wheat, the major wheat type grown in Ohio and the eastern U.S.

Ohio is historically a large milling state, 4$^{th}$ in the US. It increased its milling production by 20% from 2003 to 2008, much faster than the overall country's rate of increase, through expansion of capacity and increase in operations of newer mills. Older, inefficient mills, located away from major population areas are closing. The flour milling industry is concentrating on newer, higher-yield milling facilities that require cultivars with increased flour yield to match the improved milling equipment's efficiency.

The SWQL critically evaluates nearly all the wheat cultivars marketed from Missouri to the Atlantic seaboard. It also publishes new methods and research in the area of milling and flour quality. This research is transferred through annual technical training to 30-40 local and international food manufacturing companies by workshops held each March in Wooster, OH and through on-site and on-line support during the year.

**CURRENT FUNDING & STAFF**
Current base funding ($925,695 NTL) supports two scientists and eight full time support staff (six USDA, two Ohio State). The laboratory continues to improve efficiencies for sample evaluations; this has allowed for an increase in the total number of wheat samples evaluated per year for researchers in the eastern U.S. to 6,500, up from 4,500 three years ago. This was accomplished despite declining discretionary funds. The laboratory recently remodeled the 40 year-old chemistry and grain handling laboratories. Additional renovations to the flour milling facilities are planned as funding permits. The equipment used to measure milling quality at the SWQL is antiquated; the newest mill used for routine milling research is 50 years old and the oldest still in service is over 100 years old. In addition, milling facilities may require HVAC and mill renovations.

**PROGRAM IMPACTS**
The SWQL has supported the development of wheat cultivars that produced $1.5 B in grain per year (2005-2007 USDA Ag Statistics). Using USDA economic multiplier effects, this grain results annually in $4.0 B in food and agricultural related business and $9.9 B in economy-wide economic activity. The genetic improvement in flour yield since 1990, due to breeding programs using the SWQL, resulted in an estimated $12.7 M annually in increased flour extracted from the wheat milled in the US (2007 production at $16 per 100# of flour). This reduces consumer's food costs. It also is a component of the improved efficiency and competitiveness of the eastern U.S. milling industry. The SWQL is planning research to improve milling, wheat marketing, and human nutrition.

# Triticeae CAP (T-CAP)

## Improving barley and wheat germplasm for changing environments

**Funding:** $25 million ($5 million over 5 years) grant from the USDA National Institute for Food and Agriculture's (NIFA) Agriculture and Food Research Initiative (AFRI).

**Scientists:** 56 scientists from 28 institutions, led by Dr. Jorge Dubcovsky of the University of California at Davis and Dr. Gary Muehlbauer at the University of Minnesota.

**Goals:** The goal of the project is to develop methods to produce new varieties that minimize the damage to crops from stresses associated with climate change. It will return significant benefits to farmers by developing tools to adapt varieties planted by growers across the country.

**Long-Term Goals:** The long-term objective is a 10 percent reduction in both nitrogen and water use in barley and wheat production and a reduction of yield losses due to diseases. The main research areas are water and nitrogen use efficiency and genetic resistance to fungal diseases with an emphasis on rusts.

**Technology:** The AFRI project builds on the rapidly decreasing costs of genetic sequencing, digital multi-spectral imaging, and data management to accelerate breeding cycles. This will improve publicly-available germplasm. T-CAP will standardize methods for high-throughput field evaluation and integrating genetic and field measurements into public open-source databases (GRIN, GrainGenes, and GRAMENE). All breeding programs will be able to build upon these innovations.

**Using the World Collection of Wheat and Barley:** T-CAP scientists will systematically characterize wheat and barley lines cataloged in the National Small Grains Collection (NSGC) in addition to commercial varieties. Gene variants present in these collections will be associated with tolerance to biotic and abiotic stresses. Linking high throughput genotyping to high throughput field evaluations will accelerate the introduction of novel genes using non-GMO technology into cereal breeding programs. The new funding and genomic data will provide breeders with deeper access to useful genes present in this valuable collection.

**Training the Next Generation to Feed the World:** T-CAP will train a new generation of plant breeders in the most advanced breeding technologies helping to address a national shortage of plant scientists. The project will train a minimum of 30 new plant breeders and attract new undergraduate students to plant sciences. Scientists in the grant will develop an interactive on-line training environment to provide students with access to the best specialists in the country. This project also aims to extend state-of-the-art crop improvement technologies into minority serving universities. Importantly, this project will strengthen the national network of barley and wheat public breeding programs and provide continuing education for working plant breeders to facilitate broad adoption of the latest advances in genotyping and phenotyping.

# Historic Perspective of Wheat Characterization

This section of the Annual Report has been moved to the SWQL website, and it can be found at the link on the SWQL website. A brief summary of the beginnings of wheat characterization in the United States and information on the history of several American-grown wheat varieties are included in the Historic Perspective.

# Recent Cultivars Developed for the Eastern US

Characterized by the SWQL
Descriptions by Lon Andrews, Ed Souza and Anne Sturbaum

This section of the Annual Report has been moved to the SWQL website, and can be accessed through the link to the SWQL website. Recent Cultivars in the document were characterized by the SWQL and descriptions were collected by Lon Andrews.

# New for the 2011 Report

**Poster Abstracts from the 2011 Annual Research Review:**

- Fiber Variation in Whole-Grain Soft Wheat Flour within the United States
- Distribution of Non-Starch Polysaccharides in Soft Wheat Pilot Millstreams
- Pre-harvest Sprouting of Wheat, Alpha-Amylase Enzyme, and Falling Number
- Responses of maize (Zea mays L.) near isogenic lines carrying Wsm1, Wsm2 and Wsm3 to three viruses in the Potyviridae
- Roles of Stolbur phytoplasma and *Reptalus panzeri* (Cixiinae, Auchenorrhyncha) in the epidemiology of Maize redness in Serbia
- Development and Distribution of Male-Sterile Facilitated Recurrent Selection Populations
- The Plant Breeding and Genomics Community on eXtension: Putting Research into Practice
- QTL Mapping and Transcriptome research of PHS at MSU
- The interaction between quantitative trait loci (QTLs) associated with *Fusarium* head blight (FHB) resistance in spring wheat and *Fusarium graminearum* chemotypes (15-ADON and 3-ADON)
- Association mapping for detecting QTLs to Fusarium Head Blight and Yellow Rust resistance in Bread Wheat
- Red or White: Consumer acceptance of whole grain products
- Efficacy of Near-Infrared Reflectance Spectroscopy to Predict Fusarium Damaged Kernels and Deoxynivelanol in Red and White Wheat in Michigan
- Comparison of Different Inoculation Methods for Evaluation of FHB Resistance in Wheat Varieties
- Evaluation of Alpha Amylase Accumulation and Falling Numbers in Soft Red and Soft White Winter Wheat
- Quality Attributes of Ontario Wheats

**Soft Wheat Quality Laboratory Presentations:**

- Can Host Plant Resistance Protect Quality of Wheat from Fusarium Head Blight?
- Incorporating important biochemical attributes into breeding programs
- Breeding for Fiber Content in Wheat Flour
- Soft Wheat and Fiber
- Soft Red Winter Wheat:  Abundant, Flexible, High Quality, Continuous Improvement
- Steps Necessary for Good Quality Soft Wheat

**2011 Soft Wheat Quality Lab Focus on Research**

**Genotypes for varieties evaluated for the Wheat Quality Council (WQC) and Overseas Varietal Analysis (OVA) 2006-2010**

**Soft Wheat Quality Laboratory data from the Miag Multomat mill generated as part of the Soft Wheat Quality Laboratory's ongoing cooperative projects:**

- 2010 Regional Performance Nurseries

- 2010 Wheat Quality Council
- 2009 Overseas Varietal Analysis program of the U.S. Wheat Associates

**New Methods (See Materials and Methods):**

- Wheat moisture (Air-oven method, modified AACC 44-16)
- Flour moisture (Air-oven method, modified AACC 44-16)
- Chemically-leavened cracker baking procedure
- Soft Wheat Whole Grain NIR (DA7200)
- Advanced Mill Database Creation

*We appreciate your comments and suggestions on the 2011 Report as we begin planning for 2012*

# Soft Wheat Quality Targets for Cultivars Developed for the Eastern U.S.

Over the years the Soft Wheat Quality Laboratory (SWQL) has distributed soft wheat quality targets as part of its industry reports. These reports have included the US Wheat Associates Overseas Varietal Analysis and the Wheat Quality Council SRW Report. The targets were meant as guidelines for interpretation of the quality generated by the SWQL. Two specific guidelines are used, one for pastry quality and a second for export and cracker products.

In the past we have listed quality targets for export shipments as identical to the cracker targets. Review of the results of the past 10 years of OVA trials confirms that international customers have a similar diversity of gluten requirements as domestic US millers and bakers. The current table reflects the diverse preferences of both the US and the export market.

# Desired Ranges of Soft Wheat Quality Traits for Domestic and Export Customers

| Category / Method | Pastry Flour Desirable Parameter Range | Cracker Flour Desirable Parameter Range |
|---|---|---|
| Test Weight / Grain Condition | | |
| Test Weight | > 58 lb/bu | > 58 lb/bu |
| Shriveling Factor | < 15 % | < 15 % |
| 1000 Kernel Weight | > 27 g | > 27 g |
| Wheat Density (g/cc) | > 1.31 | > 1.31 |
| SKCS Diameter (mm) | > 2.1 | > 2.1 |
| SKCS Weight (mg) | > 2.7 | > 2.7 |
| | | |
| Field Sprouting | | |
| Viscograph (Amylograph) | > 500 bu | > 500 bu |
| Alpha-Amylase Activity | < 0.08 abs | < 0.08 abs |
| Falling Number | > 350 sec | > 350 sec |
| | | |
| Kernel Texture | | |
| Milling, Allis-Chalmers Break Flour Yield | 30 – 37 % | 25 - 37 % |
| Milling, Miag-Multomat Break Flour Yield | 24 – 35 % | 21 - 35 % |
| Milling, Quadrumat Sr. Break Flour Yield | 32 – 41 % | 25 - 41 % |
| Milling, Quadrumat Jr. Softness Equivalent | 53 – 64 % | 45 - 64 % |
| SKCS Hardness Index | < 40.0 | 10.0 - 40.0 |
| | | |
| Milling Qualities | | |
| Quadrumat Jr. Flour Yield | > 67.5 % | > 67.5 % |
| Quadrumat Sr. Flour Yield | > 62 % | > 62 % |
| Quadrumat Sr. Flour Ash | < 0.420 % | < 0.420 % |
| Allis-Chalmers Flour Yield | > 75.7 % | >75.7% |
| Allis-Chalmers Flour Ash | < 0.430 % | < 0.430 % |
| Allis-Chalmers E.S.I. | < 11.5 % | < 11.5 % |
| Allis-Chalmers Milling Score | > 52 | > 52 |
| Allis-Chalmers Friability | > 27.2 % | >27.2% |
| Miag-Multomat Flour Yield | > 71 % | > 71 % |
| Miag Damaged Starch | < 3.5 % | <3.5% |
| Miag Flour Ash | < 0.500 % | < 0.500 % |
| Agtron Color | > 50 Units | > 50 Units |

| Category / Method | Pastry Flour Desirable Parameter Range | Cracker Flour Desirable Parameter Range |
|---|---|---|
| Protein Content | | |
| Wheat Protein | 9 - 11.5 % | 9 – 12 % |
| Flour Protein | 8 - 10 % | 8 - 11 % |
| | | |
| Protein Strength | | |
| Mixograph Absorption | 52 - 58 % | 53 - 59 % |
| Mixograph Peak Time | > 2.0 min | > 2.5 min |
| Mixograph Peak Height | > 2.8 mu | > 3.0 mu |
| Alveograph Peak (Overpressure) | 24 - 38 mm | > 30 mm |
| Alveograph Length (Abscissa) | 106 -150 mm | > 150 mm |
| Alveograph Work (Deformation Energy) | 70 – 127 Joules ( x $10^{-4}$ ) | > 127 Joules ( x $10^{-4}$ ) |
| Farinograph Stability/Tolerance | 2 – 4 min | 3 - 7 min |
| Farinograph Peak Time | > 0.75 min | > 1.0 min |
| Farinograph Absorption | 51 - 55 % | 52 - 56 % |
| Acidulated Flour Viscosity (MacMichael) | 90-173 cps | 150-300 cps |
| | | |
| Solvent Retention Capacity | | |
| 50% Sucrose | <89% | <89% |
| 5% Lactic Acid | >87% | >87% |
| 5% Sodium Carbonate | <64% | <64% |
| Distilled Water | <51% | <51% |
| | | |
| Baking Qualities | | |
| Cookie, Wire-Cut Method 10-53 Width | 62.9 - 66 cm | 62.9- 66 cm |
| Cookie, Wire-Cut Method 10-53 Height | <8.4 cm | <8.4 cm |
| Cookie, Sugar-Snap Method 10-52 Width* | 17.2 - 18.0 cm | 17.2- 18.0 cm |
| Cookie, Sugar-Snap Method 10-52 Height* | < 1.65 cm | < 1.65 cm |
| Cookie, Sugar-Snap Method 10-50D Width | 48.6 - 52.1 cm | 48.6 - 52.1 cm |
| Cookie, Sugar-Snap Method 10-50D Height | < 5.7 cm | < 5.7 cm |
| Cookie Instrumental Hardness | < 26.6 kg | < 26.1 kg |

*Based on 10-52 micro-sugar snap method prior to 2008 revision. The revised method generally results in larger cookie diameters. Targets using revised 10-52 method should be 1 cm larger than values in table.

**Quality Targets for Soft Wheat – A Survey for the AACC Cincinnati Section and the USDA Soft Wheat Quality Laboratory.** Edward Souza, USDA-ARS Soft Wheat Quality Laboratory

See attached file for background data: **Miag Mill Database and Quality Targets 2011.xlsx**

**Purpose:** Build a broad picture of the uses of soft wheat and the type of flour required by customers for milling and baking. Breeders will use targets to select future varieties and industry will plan future research based on the importance assigned to specific traits.

**Methodology:** The Soft Wheat Quality Laboratory has milled over 200 samples of grain for commercial evaluation over the past 11 years. These samples were milled on a 10 flour stream, Miag Mill and submitted to overseas and domestic millers for their evaluation. We will use the information on these samples to develop a guide on future quality work.

1) We have two tables of average quality measured on wheat samples for the past 11 years. One table has quality for high protein samples (average quality of the 1/3 of samples with the greatest protein concentration, ~11.5% grain protein). The second table gives the average measured quality for grain samples with the lowest protein (average ~9.0%).
2) How do specific quality measures affect your work? Mark each quality measure as either important or not important for your business or laboratory. (+ if important/ 0 if not important or do not know).
3) What level of quality would you like? Please give a preference for a quality level. If you prefer that the quality measure be greater than the average value mark a '+'. If less mark the row with a '-'. If the value is OK or you don't have a standard for the quality measure mark it '0'.

**Your Background:**
What types of products do you or your customers make with HIGH PROTEIN flour?

What types of products do you or your customers make with LOW PROTEIN flour?

## Soft Wheat Users Preferences for Quality Targets of *HIGH PROTEIN* Wheat

Values in tables are averages of the 30% of samples milled at the SWQL with the **GREATEST** protein concentration

| | Measure | Unit | Average value | **Importance**<br>+ = important<br>0 = not important or don't know | **Preference**<br>+ = prefer a larger value<br>0 = value OK or no preference<br>- = prefer a smaller value |
|---|---|---|---|---|---|
| Grain | Grain protein | % | **11.6** | | |
| | SKCS hardness | score | **24** | | |
| Milling | Straight grade | % | **73.5** | | |
| | Break flour | % | **32.3** | | |
| | Flour protein | % (14%mb) | **9.8** | | |
| | Flour ash | % (14%mb) | **0.40** | | |
| | Falling Number | sec | **377** | | |
| | Damaged starch | % | **2.8** | | |
| | RVA Peak | cP | **3278** | | |
| Solvent retention | Water | % | **53** | | |
| | Sodium carbonate | % | **71** | | |
| | Sucrose | % | **93** | | |
| | Lactic acid | % | **105** | | |
| Alveogaph | P | mm | **36** | | |
| | L | mm | **122** | | |
| | W | ($x10^{-4}J$) | **107** | | |
| | P/L | | **0.39** | | |
| Farinograp h | Absorption | % | **53.2** | | |
| | Stability | BU | **4.2** | | |
| Wire-cut Cookie | Diameter | cm | **15.8** | | |
| | Stack ht | mm | **21.6** | | |
| | Spread factor | cm/mm | **0.74** | | |

## Soft Wheat Users Preferences for Quality Targets of ***LOW PROTEIN*** Wheat

Values in tables are averages of the 30% of samples milled at the SWQL with the **SMALLEST** protein concentration

| | Measure | Unit | Average value | **Importance**<br>+ = important<br>0 = not important or don't know | **Preference**<br>+ = prefer a larger value<br>0 = value is OK or no preference<br>- = prefer a smaller value |
|---|---|---|---|---|---|
| Grain | Grain protein | % | **9.1** | | |
| | SKCS hardness | score | **19** | | |
| Milling | Straight grade | % | **73.7** | | |
| | Break flour | % | **33.9** | | |
| | Flour protein | % (14%mb) | **7.7** | | |
| | Flour ash | % (14%mb) | **0.40** | | |
| | Falling Number | sec | **376** | | |
| | Damaged starch | % | **3.1** | | |
| | RVA Peak | cP | **3281** | | |
| Solvent retention | Water | % | **53** | | |
| | Sodium carbonate | % | **70** | | |
| | Sucrose | % | **88** | | |
| | Lactic acid | % | **93** | | |
| Alveogaph | P | mm | **35** | | |
| | L | mm | **84** | | |
| | W | ($x10^{-4}$J) | **88** | | |
| | P/L | | **0.59** | | |
| Farinograph | Absorption | % | **51.8** | | |
| | Stability | BU | **2.1** | | |
| Wire-cut Cookie | Diameter | cm | **16.0** | | |
| | Stack ht | mm | **20.9** | | |
| | Spread factor | cm/mm | **0.77** | | |

# Poster Abstracts from the 2011 Annual Research Review

## Fiber Variation in Whole-Grain Soft Wheat Flour within the United States

**Edward J. Souza and Mary J. Guttieri**
USDA-ARS Soft Wheat Quality Laboratory and Ohio State University Dept. of Horticulture and Crop Science, Wooster, OH 44691
**[Full poster can be viewed here]**

The USDA National Nutrient Database for Standard Reference is used as a standard reference for labeling and dietary formulation. The profile for whole grain wheat flour (NDB No. 20080) is largely based on hard wheat flour samples and differs from the expected profile for soft wheat whole grain flour samples for important nutrients, most notably total grain protein concentration. Also, the fiber content of the flour in the database is *imputed*, that is derived, but not measured directly.
The purpose of this study was to measure the fiber content of whole grain wheat flour prepared from soft wheat using the Integrated Total Dietary Fiber method (AACCI Method 32-45.01/AOAC Method 2009.01) and assess the range in variation.

## Distribution of Non-Starch Polysaccharides in Soft Wheat Pilot Millstreams

**Mary J. Guttieri, Clay Sneller, and Edward J. Souza**
The Ohio State University OARDC and USDA ARS Soft Wheat Quality Laboratory, Wooster, OH
**[Full poster can be viewed here]**

The general objective of commercial soft wheat milling for low water absorption flour is to optimize flour extraction while minimizing starch damage and arabinoxylan (AX) and protein concentration.
Previous millstream analyses have used mills optimized for milling hard endosperm wheat for bread applications and have analyzed grain samples of either unspecified or identifiably hard endosperm. Yet the fracture properties of soft endosperm wheat kernels profoundly influence flow through the flour mill. Because of the different milling characteristics of soft wheat, industrial mills typically are optimized for this task. A cross-section of seven eastern U.S. soft winter wheat genotypes were milled on a Miag Multomat flour mill flowed for soft wheat milling. Flour yield, ash, protein concentration, and water-extractable (WE-) non-starch polysaccharide concentration were measured on all ten streams.

## Pre-harvest Sprouting of Wheat, Alpha-Amylase Enzyme, and Falling Number

**Edward J. Souza[1], Mary Guttieri[2], Robert Kratochvil[3], and Anne Sturbaum[1]**
[1] USDA-ARS, Soft Wheat Quality Lab, Wooster, OH
[2] Ohio State University, Wooster, OH
[3] University of Maryland, College Park, MD
**[Full poster can be viewed here]**

Pre-harvest sprouting (PHS) in wheat occurs when the crop is exposed to rain after a field reaches maturity. Sprouting grain produces **α-amylase**, an enzyme that rapidly breaks starch into simple sugars. Grain values decline rapidly as the level of alpha amylase increases, and grain elevators pay lower prices for sprouted grain since limited options exist for resale. In cases of severe sprouting, grain is acceptable for animal feed, only. We evaluated trials in Maryland for three years measuring PHS with Falling Number and Alpha Amylase assays in collaboration with the University of Maryland. The main conclusions were:

1) cultivars differ greatly in their sensitivity to moisture/rainfall after maturity, with Coker 9553, McCormick, SS 8302, and SS 8404 being the least prone to pre-harvest sprouting as measured by Hagburg Falling Number Test, and
2) α-amylase enzyme activity, measured indirectly through falling number, often does not increase immediately in all cultivars and frequently is not significant until falling number values are significantly less than 300 seconds.

Cultivar information is directly useful for grower planting decisions. Data is available on the USDA-ARS Soft Wheat Quality web site.
Buyers should be encouraged to purchase moderate falling number grain for higher-end use since α-amylase levels are undetected at 240 sec to 350 sec FN.

## Responses of maize (Zea mays L.) near isogenic lines carrying Wsm1, Wsm2 and Wsm3 to three viruses in the Potyviridae

**Mark W. Jones[1], Emily C. Boyd[2] and Margaret G. Redinbaugh[1,2]**
[1]USDA, ARS Corn and Soybean Research Unit
[2]Department of Plant Pathology, Ohio State University, Ohio Agriculture Research and Development Center, Wooster, OH, USA.

Genes on chromosomes six (*Wsm1*), three (*Wsm2*) and ten (*Wsm3*) in the maize (*Zea mays* L.) inbred line Pa405 control resistance to Wheat streak mosaic virus (WSMV), and genes in the same chromosomal regions control resistance to Maize dwarf mosaic virus (MDMV) and Sugarcane mosaic virus (SCMV). Near isogenic lines (NIL) carrying one or two of these genes were developed by introgressing regions of the respective chromosomes into the susceptible line Oh28, and tested for their responses to WSMV, MDMV and SCMV in the field and greenhouse. F1 progeny from NIL x Oh28 were also tested. *Wsm1*, or closely linked genes, provided resistance to all three viruses, as determined by symptom incidence and severity. *Wsm2* and *Wsm3* provided resistance to WSMV. *Wsm2* and/or *Wsm3* provided no resistance to MDMV, but significantly

increased resistance in plants with one *Wsm1* allele. NIL carrying *Wsm1*, *Wsm2* and *Wsm3* had similar SCMV resistance in the field, but NIL with *Wsm2* and *Wsm3* were not resistant in the greenhouse. Addition of *Wsm2* to *Wsm1* increased SCMV resistance in the field. For all viruses, symptom incidence was higher in the greenhouse than in the field, and relative disease severity was higher in the greenhouse for WSMV and MDMV. An Italian MDMV isolate and the Ohio SCMV infected the *Wsm1* NIL, while the Ohio MDMV and Seehausen SCMV isolates did not. Our results indicate that the three genes, or closely linked loci, provide virus resistance. Resistance is influenced by interactions among the genes, the virus species, the virus isolate and the environment.

## Roles of Stolbur phytoplasma and *Reptalus panzeri* (Cixiinae, Auchenorrhyncha) in the epidemiology of Maize redness in Serbia

**J. Jović[1] , T. Cvrković[1], M. Mitrović[1], S. Krnjajić[1], M.G. Redinbaugh[2*], R.C. Pratt[3], R.E. Gingery[2], S.A. Hogenhout[4] and I. Toševski[5]**
[1]Institute for Plant Protection and Environment, Department of Plant Pests, Banatska 33, 11080 Zemun, Serbia. USDA, ARS Corn and Soybean Research[2]; Departments of [2]Plant Pathology [3]Horticulture and Crop Science and [4]Entomology, The Ohio State University/Ohio Agriculture Research and Development Center, Wooster, OH 44691. [5]CABI Bioscience, Centre Switzerland, 1 Rue des Grillons, 2800 Delémont, Switzerland

Maize redness (MR), a disease causing midrib, leaf and stalk reddening and abnormal ear development in maize, has been reported from Serbia, Romania and Bulgaria for 50 years. Recent epiphytotics reduced yields by 40-90% in southern Banat, Serbia. MR was recently associated with the presence of the stolbur phytoplasma (Duduk and Bertaccini Plant Dis. 90: 1313), although the epidemiology of the disease remained unknown. Diseased fields in southern Banat were surveyed for potential vectors of the phytoplasma during 2005 and 2006, and high populations of *Reptalus panzeri* were found. In affected fields, 20% of the *R. panzeri* individuals and 85% of symptomatic maize plants carried the stolbur phytoplasma. When stolbur phytoplasma-infected *R. panzeri* were introduced into insect-free mesh cages containing healthy maize plants, midrib and leaf reddening developed on 48% of plants and stolbur phytoplasma was detected in 90% of the symptomatic plants. No symptoms or phytoplasma-positive plants were found in cages without insects. These data indicate that MR symptoms are associated with the stolbur phytoplasma. To identify potential reservoirs of pathogen, *Convolvus arvense* and several other perennial weeds collected from the test plots in southern Banat were tested for the presence of stolbur phytoplasma, but none were infected. However, *R. panzeri* larvae collected from the roots of infected maize plants in late October, 2006 were positive for the phytoplasma. These results indicate that *R. panzeri* is likely to be a major vector of MR, as it is both abundant in affected fields, can transmit the stolbur phytoplasma, and the overwintering form of the insect is infected with the pathogen.

## Development and Distribution of Male-Sterile Facilitated Recurrent Selection Populations

**J. Shoots, M. Guttieri, F. Kolb, J. Lewis, A. McKendry, H. Ohm, C. Sneller, M.E. Sorrells, E. Souza, D. Van Sanford, J. Costa, C. Griffey, S. Harrison, J. Johnson, and P. Murphy**

**[Full poster can be viewed here]**

Recurrent selection is a breeding procedure with the objective of increasing the frequency of desirable alleles for one or more traits while maintaining a high level of variability in the population. Inter-mating among selected parents each generation allows recombination to occur thus combining genes from different sources. Male sterility in a self-pollinated species provides a mechanism to easily produce many crosses. Male-sterile plants to not produce viable pollen. Thus, any seed from a sterile plant must be a hybrid via pollen from a male-fertile plant. In contrast, hand pollination requires laborious manual emasculation and pollination.
Male-sterile recurrent selection in wheat derives its power from recombination of sources of genetic variation for a specific trait and intensity of selection due to large population size that results from many crosses. Progress from selection when recombining genetic sources of FHB resistance is directly related to the amount of genetic variation for the trait in the population and the identification of parents with a high level of expression of the desired trait.
The dominant male-sterile gene was utilized rather than the recessive gene because the progenies of the male-sterile plants always segregate 1:1 for sterility and a generation of selfing is not required to obtain true-breeding fertile genotypes.
Our objective is to create four populations with FHB resistance adapted to different regions of the eastern U.S.

## The Plant Breeding and Genomics Community on eXtension: Putting Research into Practice

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Plant breeding improves the quality and output of agricultural crops. Accelerated gains in quality and output may be achieved by making use of genome sequence data. Understanding variation in genome sequence between crop species and wild relatives can be useful in crop improvement to the extent that it helps predict variation for agriculturally important traits. The plant breeding and genomics community of practice on eXtension.org was formed to help plant breeders translate basic research in genomics into practice through content that emphasizes emerging sequence databases, genotyping techniques, and analytical methods. The community, consisting of public and private researchers and educators, has also developed content for end users such as growers and processors. Content includes tutorials, case studies, reviews, and data sets in webinar, video, and text formats with short courses coming.

## QTL Mapping and Transcriptome research of PHS at MSU

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Pre-harvest sprouting (PHS) is the precocious germination of grains in the ear following physiological maturity. It usually occurs during prolonged cool wet condition, as experienced in Michigan in 2008 and 2009. It reduces wheat yield and wheat flour quality, which is a critical concern of regional wheat industries (including millers and cereal companies). It is historically known that the red wheat is more resistant to PHS than white wheat but the mechanism behind this relationship is still unclear. Red seed coat color is controlled by three homologous genes on chromosome 3. Two studies will be described in this poster. In one of them we will determine the proportion of PHS resistance that each of the red genes confers. To do this, a red x white spring wheat Recombinant Inbred Line (RIL) population is being evaluated for α-amylase level and falling number values with and without PHS inducing conditions. QTL mapping of the PHS trait and its relation with the three red genes will be determined. The second study employs transcriptome analysis of the PHS response. Transcriptome analyses will greatly enhance our understanding at the gene expression level of the pre-harvest sprouting biological pathway and identify the candidate genes for further research.

## The interaction between quantitative trait loci (QTLs) associated with *Fusarium* head blight (FHB) resistance in spring wheat and *Fusarium graminearum* chemotypes (15-ADON and 3-ADON)

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*Fusarium* head blight (FHB) caused by *Fusarium graminearum* (Schwabe) is a devastating wheat disease that results in decreased yield, quality and mycotoxin deoxynivalenol (DON) accumulation. Two different chemotypes of *F. graminearum* (15-ADON and 3-ADON) have been identified in North America. The chemotypes produce total DON plus slightly different forms of DON called 15-ADON and 3-ADON. In some parts of North America, more 3-ADON chemotypes have been identified recently; this is a concern because the 3-ADON chemotype is more toxic than the 15-ADON chemotype. The most practical way to control FHB is through the development of resistant cultivars through conventional breeding or marker assisted selection (MAS).

The objective of this study was to investigate if there is an interaction between quantitative trait loci (QTLs) associated with FHB resistance in selected spring wheat lines from previously mapped 'Wuhan/Nyubai' population (Somers et al., 2003) and *F. graminearum* 15-ADON and 3-ADON chemotypes. The trials were planted in 2008, 2009 and 2010 in Ridgetown, Ontario and were designed as a split plot (main plot=genotype of wheat, sub plot= *F. graminearum* isolate) with three replicates. At 50% anthesis, single *F. graminearum* isolates of three 15-ADON and three 3-ADON chemotypes were sprayed individually on each plot using a backpack sprayer; control plots were sprayed with water. Visual symptoms were recorded for each plot as incidence and severity and FHB index was calculated as severity x incidence/ 100. Harvested grain was analyzed for DON content using ELISA method (Diagnostix Ltd, Mississauga,ON). In all three years, the highest DON accumulation occurred after inoculation with a 3-ADON isolate indicating that 3-ADON chemotypes have potential to cause higher levels of DON accumulation in wheat. In 2008, significant interaction was detected between *F. graminearum* chemotypes and QTLs for FHB index, but no for DON level. In 2008 and 2009 wheat line 392 (no QTL) had the highest DON accumulation, while wheat line 371-3Bs has the lowest DON accumulation.

## Association mapping for detecting QTLs to Fusarium Head Blight and Yellow Rust resistance in Bread Wheat

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Fusarium Head Blight (FHB), mainly caused by *Fusarium graminearum*, and Yellow Rust (YR), caused by *Puccinia striiformis*, are two of the most important wheat diseases around the world. These diseases can cause severe yield reduction and grain quality deterioration in wheat. In the case of FHB, there is an additional concern related with mycotoxins accumulation in the kernel. Breeding for resistance for both diseases has been considered as the most practical strategy of control. MSU, CIMMYT, and INIAP have started a project to identify QTLs for FHB and YR resistance in spring wheat germplasm. Association Mapping will be the approach to the identification of valuable QTLs in a wheat population composed with 297 genotypes. The population was developed by CIMMYT and it includes breeding lines carrying many interesting QTLs that need to be identified. The population will be genotyped with Simple Sequence Repeat (SSR) markers linked to agronomic traits and 9,000 Single Nucleotide Polymorphism (SNP) markers by Illumina Infinium SNP genotyping facility at MSU. The phenotypic data will be collected in 2011 and 2012 from evaluations in Mexico and Ecuador from separated nurseries for each disease. Artificial inoculations for FHB will be done, and in the case of YR, susceptible spreaders will be used to assure good levels of disease pressure. Agronomic and quality variables will be recorded. In addition to standard agronomic traits, data will be recorded for FHB and YR on severity, incidence, reaction type, and mycotoxin accumulation. Data will be analyzed with TASSEL v3.0 considering the mixed-model approach. Among the expected results is

the development of an Association Map of loci linked to FHB and YR resistance, identifying markers that will be useful for MAS, identification of resistant germplasm and resistance sources for FHB and Yellow rust in the population of study, development of the local capacity of the Wheat Program in Ecuador and the developing the experience and expertise at MSU for Association Mapping. In addition, lines from CIMMYT are regularly used for variety releases and breeding around the world, therefore, this project will expand the utility of these lines for wheat breeders in general. In this poster the plan of research will be more thoroughly presented.

## Red or White: Consumer acceptance of whole grain products

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The consumption of whole grains is being encouraged by numerous health organizations due to a number of associated health benefits. However, increased use of whole grains has raised concerns around product acceptability due to the presence of characteristic flavours that some consumers consider to be unacceptable. The objective of this study was to investigate consumer acceptance of products made from commercial whole grain flours produced from red or white wheats and with fine or coarse particle sizes. Intermediate (bread) and low (cracker) moisture products were investigated. Intermediate and low moisture products were produced from hard and soft flour, respectively. Red wheat products were liked significantly more in terms of flavour and overall for the intermediate moisture and low moisture products. However significant colour*particle size interactions were observed for appearance, texture and strength of aftertaste for the intermediate moisture products and flavour and strength of aftertaste for the low moisture products.

## Efficacy of Near-Infrared Reflectance Spectroscopy to Predict Fusarium Damaged Kernels and Deoxynivelanol in Red and White Wheat in Michigan

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Michigan State University annually evaluates the Michigan State Performance Trial (MSPT) entries for Fusarium head blight (FHB) resistance. The MSPT consists of both red and white genotypes that vary in visual field symptoms of FHB, Fusarium Damaged Kernels (FDK) and deoxynivalenol (DON) levels. It has been previously reported that white wheat accumulates higher amounts of DON than red wheat (Knott, Van Sanford et al. 2008). In addition, near-infrared spectroscopy (NIRS) predictions for DON levels have been investigated, in general However, the effect of grain color (red vs. white) in NIRS predictions of FDK and DON have not, to our knowledge, been investigated. In this poster we will present data of visual field symptoms of FHB (incidence, severity,

index), FDK, DON and NIRS predictions of both FDK and DON when grain color is considered for the 2009 MSPT.

Knott, C. A., D. A. Van Sanford, et al. (2008). "Comparison of selection methods for the development of white-seeded lines from red x white soft winter wheat crosses." Crop Science **48**(5): 1807-1816.

## Comparison of Different Inoculation Methods for Evaluation of FHB Resistance in Wheat Varieties

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Fusarium head blight (FHB) in wheat is caused by the fungus *Fusarium graminearum*, which infects wheat heads at anthesis. Weather conditions such as humidity and temperature play an important role in the extent of infection. Several Mechanisms have been proposed for host resistance, including resistance to the incidence of disease (Type I) and resistance to spread of infection (Type II). Several screening methods have been researched for successful prediction of resistance to FHB infection; the most prominent being spray and point inoculation which measure Type I and Type II resistance respectively.
The objective of this study was to compare the efficiency of the following methods for evaluating resistance to FHB: spray inoculation in the greenhouse followed by bagging, spray inoculation in the field followed by bagging, and traditional field method using grain spawn inoculum. The study includes 16 varieties adapted to Michigan, which includes both soft red and soft white winter wheat lines with varying levels of resistance to FHB. Comparisons are made on % incidence, % severity and Fusarium damaged kernels (FDK).

## Evaluation of Alpha Amylase Accumulation and Falling Numbers in Soft Red and Soft White Winter Wheat

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Michigan has experienced two recent years (2008 and 2009) of severe Pre-Harvest Sprouting (PHS) in wheat. Alpha-amylase is an important component of PHS and the falling number test is used by industry to identify sprouted wheat that is unacceptable for various food products. Red wheat is, in general, more resistant to PHS than white wheat. The objective of this study was to evaluate wheat cultivars adapted to Michigan for the quantity of α-amylase and the corresponding falling numbers at three maturity time-points (before physiological maturity [PM], at PM and post PM) in the absence and presence of PHS inducing conditions. In 2009, twenty soft winter wheat genotypes (10 red and 10 white) with varying levels of susceptibility to PHS were planted in two locations (East Lansing and Clarksville, MI) in a three-replication alpha lattice design. In 2010, twenty-four genotypes were planted in three locations (East Lansing, Saginaw and Ingham). Spikes were collected three days before PM, at PM, and three days post PM. Immediately following collection, samples were frozen and then freeze-dried and threshed. In 2010 a subsample from each plot was artificially misted for 48 hours to induce PHS, while a second subsample was non-misted for the same period of time as a control, after which they were frozen, freeze-dried and threshed. Threshed samples were milled and evaluated for α-amylase activity and Falling Number (FN) values. The 2009 data, in which samples were harvested in non-PHS conditions, showed clear trends in the reduction of α-amylase and the increase in FN during the progression of maturation. In addition, α-amylase and FN data were significantly correlated. Significant differences for α-amylase levels and falling number were found between genotypes within each wheat class (red and white) and at the three mature time points. α-amylase activity levels converged towards similar values at 3 days post PM, though a similar convergence was not observed in FN values. This base level of α-amylase and FN that has been established is revealing in and of itself. The 2010 data, which includes α-amylase and FN in both non-PHS and PHS conditions, will reveal if the base level of α-amylase and FN determined from non-PHS conditions has a predictive value for PHS conditions, and also indicate the overall levels of resistance of PHS in wheat adapted to Michigan. Both 2009 and 2010 data will be presented.

## Quality Attributes of Ontario Wheats

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**Abstract**
Recent consumer attitude toward food and health for enhancing the quality of life and preventing chronic diseases through improved diet has promoted research on the bioactive components of agriculture products. Wheat is an important agricultural and dietary commodity worldwide. Research has shown that whole grain wheat and wheat bran extracts possess antioxidants that protect against oxidation of biologically important molecules such as DNA, proteins and membrane lipids. The ultimate goal of this research is to expand the market for whole wheat and wheat-based functional foods in Ontario through identification and development of wheat lines that have potential health benefits. 34 soft wheat varieties/lines grown in different locations in Ontario were screened for their bioactive compounds of the whole grain flour. Total dietary fiber ranged from 11.5 to 15.1%,, β-glucan ranged from 0.65 to 0.97%, total phenolic content ranged from 902 to 1231 μg/g, and antioxidant capacity ranged from 82 to 106. Protein quality of the whole grain flour was estimated using Gluten Peak Tester (GPT) and SRC-lactic acid tests. The results indicated that Ontario soft wheat could be a rich source of bioactive compounds. Furthermore, wheat varieties grown in different locations had different quality attributes that could be exploited for food uses.

# Multi-Year Analysis of Miag Flour Mill Evaluation 2010

Average values of Miag Multo-mat milling evaluations of soft winter wheat that appeared more than once in the Wheat Quality Council and US Wheat Associates Overseas Varietal Analysis, 2001 to 2009 are included in the attached file:
**Miag Mill Database and Quality Targets 2011.xlsx**

Alveograph and Farinograph data from various cooperators. All other data from the USDA Soft Wheat Quality Laboratory.

## Prediction of Wire-cut Cookie Quality in Long-flow Milled Flour Samples

### Purpose of study

1. To measure the reproducibility of industry panel evaluations of new wheat varieties.
2. To illustrate relationships among wheat quality measures.
3. To identify the most valid tests for predicting wire-cut cookie quality.

### Summary

Differences among samples in the OVA study for water absorption characteristics (including Solvent Retention Capacity measures), cookie baking quality, and Alveograph P values have large genetic components and reflect differences among varieties as well as the different growing environments in which the varieties were grown. Flour protein, Alpha-amylase activity (falling number), Farinograph stability, Alveograph P and P/L ratio reveal almost no genetic variation in the OVA studies. Differences among the OVA samples are due almost entirely to the production environment where the sample was produced.

In this set of samples, Alveograph parameters, flour protein concentration, and solvent retention capacity tests provide complementary information to the prediction of baked product quality. The best prediction models for cookie quality used flour protein concentration, Alveograph measures and solvent retention capacity tests in combination. Flour samples with lower protein levels, smaller Alveograph P and L values, and smaller water and sucrose SRC values produced larger and more tender cookies.

### General description of the dataset

We evaluated 142 samples of soft red and white winter wheat for the US Wheat Associates Overseas Varietal Analysis (OVA) and the Wheat Quality Evaluation Councils (QEC), from 2001 to 2007. Samples were provided from a variety of sources, and were typically from commercial grain samples. In each year samples often came from multiple fields and locations. All samples were milled on the Miag Multomat. Straight grade flour was evaluated at the USDA Soft Wheat Quality Laboratory using AACC methods. In addition for the Wheat QEC samples, Alveograph data was provided by Kraft Foods Corporation and Farinograph data by the Mennel Milling Company. For the OVA, samples Alveograph and Farinograph data was provided by US Wheat Associates.

Questions often arise about the interpretation of results of long-flow milling for the US Wheat Associates. One set of questions focuses on customer preferences. The discussion within each country is intended to shed light on the preferences of each customer. A second set of questions concerns the reliability of the data and the interrelatedness of the quality measures. This study was intended to address the second set of questions. Rather than presenting the results in a narrative, the results are summarized in response to common questions that are asked about the OVA results and soft wheat quality in general.

***Question #1. What is the level of reproducibility for a variety's quality when evaluated in quality councils?***

How reproducible are flour quality measures that are evaluated in long-flow evaluations such as the Overseas Varietal Analysis (OVA)? The differences between the lines include genetic differences, differences due to location, and the particular growing year. When comparing samples, it is easiest to simply acknowledge that the samples are different and interpret how the cooperators respond or score the differences. Yet, varieties that appear in the OVA often are recognizable and reflect differences that were apparent in replicated testing conducted with smaller flour mills. To test which flour measure differences are likely due to genetic difference and which largely reflect the environment, we analyzed a subset of the varieties included in the analysis. By examining only the varieties that were repeated in the analysis, we could measure what the variance and the precision were for single observations of quality. The varieties and trials in which they were repeated are given in Table 1. The analysis of variance in Table 2 quantifies the portion of the differences between samples that is due to true genetic differences between varieties and the proportion of the differences that is due to environment or error in measuring the quality.

**Discussion of repeatability**

In Table 2, the mean square terms for flour measures that are followed by stars indicate that the differences between samples have significant genetic basis. Environment and error also contribute to the differences in varieties, but the genetic difference between samples is greater than these background effects. Differences among varieties for wire-cut cookie diameter and SRC measures are characteristic of the variety. They have the largest variance attributed to genetics relative to the background effects of environment, years, and random error. Recommendations for changes to the soft red winter wheat class for these flour traits with a genetic basis can be readily addressed through breeding and genetics.

In contrast to water absorption characteristics, some traits have no obvious genetic component of variation in the samples evaluated by the OVA and QEC programs. Examples of these are Alveograph L and P/L ratios, which are important measures of flour quality for many soft wheat product manufacturers. Selecting varieties for

Alveograph L may be of limited value; the range in variation for L or P/L that is needed for different soft wheat products will likely derive from the range in environmental differences in the places where soft wheat is produced. Genetic variation may occur for some of the traits that do not have significant variety effects in this test. Grain hardness is a good example of this. Once hard wheats have been excluded from a sample of varieties, genetic differences in grain hardness are difficult to quantify. Traits like flour yield and break flour yield were controlled by both environment and genetics, with only moderate amounts of variation attributed to variety.

**Table 1. Varieties repeated in the analysis of soft red wheat using long-flow milling.**

| Cultivar | replicates | Trials where the variety was tested |
|---|---|---|
| Armor 3035 | 4 | 2001 OVA, 2002 OVA, 2003 OVA, 2005 OVA |
| Armor 4045 | 3 | 2001 OVA, 2002 OVA, 2003 OVA |
| AGS 2000 | 3 | 2005 OVA, 2006 QEC, 2007 QEC |
| Beretta | 2 | 2005 OVA, 2006 QEC |
| Bravo | 2 | 2003 QEC, 2006 OVA |
| Caldwell | 4 | 2001 QEC, 2002 QEC, 2003 QEC |
| Coker 9184 | 3 | 2002 OVA, 2004 OVA, 2004 QEC |
| Coker 9553 | 2 | 2006 OVA, 2007 OVA |
| Coker 9663 | 5 | 2001 OVA (2 samples), 2002 OVA, 2004 OVA, 2005 OVA |
| Dominion | 2 | 2004 QEC, 2006 OVA |
| Featherstone 176 | 2 | 2004 QEC, 2006 QEC |
| Hopewell | 2 | 2006 OVA, 2007 OVA |
| Magnolia | 2 | 2006 QEC, 2007 OVA |
| McCormick | 2 | 2001 QEC, 2007 OVA |
| Natchez | 4 | 2002 OVA, 2003 OVA, 2005 OVA, 2006 OVA |
| NC Neuse | 2 | 2006 OVA, 2007 OVA |
| Pioneer 25R47 | 3 | 2002 QEC, 2003 QEC, 2007 OVA |
| Pioneer 26R12 | 2 | 2002 QEC, 2004 OVA |
| Pioneer 26R15 | 2 | 2003 QEC, 2005 OVA |
| Pioneer 26R24 | 4 | 2001 OVA, 2002 OVA, 2003 OVA, 2004 OVA |
| Pioneer 26R58 | 2 | 2002 QEC, 2005 OVA |
| Panola | 2 | 2005 OVA, 2006 OVA |
| Patterson | 2 | 2004 QEC, 2006 QEC |
| Roane | 2 | 2001 OVA, 2004 OVA |
| Sisson | 2 | 2002 OVA (2 Samples) |
| Tribute | 2 | 2002 OVA, 2007 OVA |
| USG 3209 | 5 | 2001 OVA, 2002 OVA, 2004 OVA, 2006 QEC, 2007 QEC |

**Table 2. Wheat quality traits analysis of variance and distribution of variety means for varieties that appeared repeatedly in Overseas Varietal Analysis and Wheat Quality Council, 2001 to 2007.**

| | | Mean square terms | | | Distribution | | | |
|---|---|---|---|---|---|---|---|---|
| Trait | samples | Variety | | Error | Average | Max. | Min. | Units |
| Grain hardness | 57 | 116.1 | | 80.8 | 23.5 | 46.1 | 10.4 | 0 to 100 |
| Flour protein | 72 | 1.056 | | 0.658 | 8.38 | 10.04 | 7.21 | g 100 $g^{-1}$ |
| Flour yield | 72 | 3.62 | * | 1.87 | 73.4 | 75.7 | 71.3 | g 100 $g^{-1}$ |
| Break flour yield | 72 | 46.3 | * | 26.0 | 32.6 | 42.2 | 24.1 | g 100 $g^{-1}$ |
| Flour ash | 72 | 0.00316 | * | 0.00152 | 0.395 | 0.474 | 0.346 | g 100 $g^{-1}$ |
| Falling Number | 72 | 3870 | | 2410 | 392 | 469 | 325 | Sec |
| Alpha amylase | 65 | 0.00186 | | 0.00641 | 0.112 | 0.199 | 0.089 | absorp. |
| Starch damage | 72 | 1.502 | *** | 0.507 | 2.84 | 3.93 | 1.30 | % |
| RVA Peak | 72 | 641000 | | 865000 | 3629 | 4690 | 2814 | cP |
| RVA Final | 72 | 641000 | | 688000 | 3755 | 4441 | 2863 | cP |
| Lactic Acid SRC | 72 | 280.8 | *** | 80.8 | 101.1 | 116.2 | 79.8 | g 100 $g^{-1}$ |
| Sucrose SRC | 72 | 58.67 | *** | 20.37 | 90.2 | 101.0 | 82.6 | g 100 $g^{-1}$ |
| Sodium Carb. SRC | 72 | 38.67 | *** | 11.32 | 71.0 | 79.7 | 64.2 | g 100 $g^{-1}$ |
| Water SRC | 72 | 13.03 | *** | 4.61 | 53.4 | 60.2 | 50.7 | g 100 $g^{-1}$ |
| Farinograph absorp. | 63 | 6.50 | ** | 2.41 | 52.7 | 58.1 | 50.5 | g 100 $g^{-1}$ |
| Farinograph stability | 63 | 2.39 | | 3.50 | 2.8 | 7.1 | 1.2 | Min |
| Alveograph P | 72 | 222.22 | ** | 88.22 | 38 | 60 | 24 | Mm |
| Alveograph L | 72 | 1520 | | 1030 | 102 | 151 | 46 | Mm |
| Alveograph W | 72 | 1492 | * | 817 | 107 | 163 | 52 | ($x10^{-4}$J) |
| Alveograph P/L | 72 | 0.148 | | 0.160 | 0.500 | 1.008 | 0.190 | |
| Cookie diameter | 72 | 0.674 | *** | 0.225 | 15.73 | 16.95 | 14.72 | Cm |
| Cookie height | 72 | 3.215 | *** | 0.978 | 21.4 | 23.7 | 18.7 | Mm |
| Shape factor | 72 | 0.01002 | *** | 0.00277 | 0.740 | 0.911 | 0.648 | |
| Snapping force | 72 | 113200 | * | 62800 | 2390 | 2807 | 1995 | G |
| Force/diameter | 72 | 2640 | ** | 1040 | 305 | 366 | 244 | g $cm^{-1}$ |

*, **, *** F-test for variety is significant at the 95%, 99%, and the 99.9% confidence interval, respectively.

***Question #2. If a wire-cut cookie is the standard for soft wheat baked products, what quality measures of grain and flour are correlated to wire-cut cookie measurements?***

Among the samples in the OVA and QEC studies were a wide range of flour types, large enough to produce good correlation studies of what flour traits are correlated to cookie quality. For our analysis we excluded samples that would normally not be shipped into export channels. Samples with less than 300 sec FN were excluded from the correlation (12 samples were excluded). Correlations from the 2001 to 2007 OVA and QEC panels are based on 130 samples with falling number values greater than 300 sec.

**Discussion of Correlations**

The measures with the least effect were flour ash, damaged starch, and Alveograph P/L ratios. These measures can be significantly related to cookie quality, but were not in this study due to the sampling and flour milling methods. Flour ash and damaged starch variation were minimal because the same streams were combined for each flour sample. Differences in flour ash likely had more to do with whole grain ash concentration than degree of inclusion of aleurone layers into the flour.

Many of the measures of wheat quality are correlated to one or more of the measures of cookie quality. The best predictor of cookie shape (diameter, height, and shape factor) was water SRC with negative correlation coefficients of greater than -0.5 to each cookie measure ($p<0.01$). Farinograph absorption, a more common measure of flour water absorption than water SRC, had smaller correlation coefficients but also was significantly correlated to cookie shape. The best predictors of cookie texture were sucrose SRC, final Rapid Visco-Analyzer viscosity, flour protein and measures of gluten strength (lactic acid SRC, Alveograph W, and Farinograph measures). Previous work suggests that many of the flour quality measures also are inter-correlated with each other and may predict the same underlying factors of the flour quality; for example, water SRC and Farinograph absorption measure similar characteristics of the flour. When there is a choice of tests to use, which is better and which should be used together in combination for the best prediction of flour functionality?

**Table 3. Correlation wire-cut cookie quality with grain and flour characteristics measured on 130 samples of wheat evaluated in the OVA and QEC, 2001 to 2007**

| | Cookie diameter | Cookie height | Shape factor | Snapping force | Force/ Diameter |
|---|---|---|---|---|---|
| Grain hardness | -0.39** | 0.21* | -0.30** | 0.10 | 0.21* |
| Flour protein | -0.01 | 0.12 | -0.09 | 0.26** | 0.24* |
| Straight grade flour | 0.11 | -0.12 | 0.11 | -0.19* | -0.21* |
| Break flour yield | 0.53** | -0.16 | 0.32** | -0.02 | -0.17 |
| Damage starch | -0.08 | 0.14 | -0.11 | 0.07 | 0.09 |
| Flour ash | 0.05 | 0.22* | -0.12 | 0.15 | 0.12 |
| Falling number | -0.28** | 0.21* | -0.25** | 0.11 | 0.18* |
| Alpha amylase | -0.01 | -0.03 | 0.02 | 0.00 | 0.00 |
| RVA Peak viscosity | 0.40** | 0.00 | 0.16 | 0.33** | 0.18* |
| RVA Final viscosity | 0.16 | 0.13 | -0.02 | 0.35** | 0.27** |
| Ratio of Peak to Final | 0.46** | -0.21* | 0.31** | 0.10 | -0.04 |
| Lactic acid SRC | -0.21* | 0.24* | -0.25** | 0.30** | 0.32** |
| Sucrose SRC | -0.40** | 0.39** | -0.42** | 0.40** | 0.48** |
| Sodium Carbonate SRC | -0.42** | 0.55** | -0.53** | 0.19* | 0.29** |
| Water SRC | -0.50** | 0.51** | -0.53** | 0.06 | 0.20* |
| Alveograph P | -0.50** | 0.40** | -0.46** | 0.24* | 0.36** |
| Alveograph L | -0.12 | -0.02 | -0.03 | -0.10 | -0.06 |
| Alveograph W | -0.41** | 0.22* | -0.31** | 0.12 | 0.22* |
| Alveograph P/L ratio | -0.09 | 0.09 | -0.11 | 0.04 | 0.06 |
| Farinograph absorption | -0.36** | 0.37** | -0.39** | 0.10 | 0.20* |
| Farinograph stability | -0.24** | 0.15 | -0.20* | 0.18 | 0.23** |

*, ** F-test for variety is significant at the 95% and 99% confidence interval, respectively

***Question 3. Are there prediction models based on simple measurements that can predict cookie diameter?***

In this set, simple measures are considered to be grain hardness, flour protein, flour ash and falling number. These are simple analyses that may be performed at grain receiving. They also are part of tender offers for international grain shipments. This dataset uses 111 samples, excluding samples with less than 300 sec. falling number. This analysis is different from the correlation analysis listed above because we can have more than one predictor of cookie quality. In reality, this is closer to most specification used in industry where multiple quality measures are used in the purchase and sale of grain and flour. We used step-wise addition of following variables: hardness, protein, falling number and ash.

**Discussion of simple predictions**

The strength of the prediction model in this analysis is measured by the $R^2$ value in Table 4. The number is the percent of variation in cookie characteristic that is predicted by the best combination of the simple measures of grain hardness, protein, falling number and flour ash. For cookie diameter, 20% of the variation in the diameter of cookies can be predicted by the combination of grain hardness and falling number. In this model, lower values of grain hardness (increasingly soft grain) and lower falling number values resulted in larger (better) cookies.

The reduction in falling number values may be an important point. Below 300 seconds differences in falling number values for samples is largely due to alpha-amylase activity, and these samples were excluded from the analysis. However, differences above 300 seconds also occur. They are likely due to particle size and non-gluten networks within the grain such as arabinoxylans. Very high falling number values may be a sign of large particle size and increased arabinoxylans concentration, which may be undesirable for cookies.

The other prediction models were poorer than the model for diameter ($R^2$ values of less than 20%). Flour ash appears a second variable in several of the models. Flour protein in combinations with other variables predicts the texture parameters of the cookies, with greater protein concentration associated with increasing force to snap the cookie. Can the prediction of cookies be improved by adding more complex flour measurements?

**Table 4. Simple quality measures that predict wire-cut cookies**

| Cookie characteristic | Prediction model | $R^2$ |
|---|---|---|
| Diameter | 17.7 – 0.0232 Hardness – 0.0035 Falling Number | 0.20 |
| Height | 17.7 + 0.0304 Hardness + 7.38 Flour ash | 0.09 |
| Shape factor | 0.937 – 0.00203 Hardness – 0.000367 Falling Number | 0.13 |
| Snapping force | 1106 + 84.9 Flour protein + 1456 Flour ash | 0.11 |
| Force/Diameter | 142.9 + 9.11 Flour protein + 0.217 Falling Number | 0.09 |

***Question 4. Traditional instruments to measure cookie quality are the Farinograph and Alveograph. What are their relationships to cookie quality?***

We fit the models for predicting cookie quality using flour protein and then adding in the flour quality measures from either the Farinograph (Table 4) or Alveograph (Table 5). In these models we will continue to use flour protein in the models as cookie formulas make adjustments for protein. Terms such as flour protein or water absorption were retained in the multiple regression models only if they were significant predictors of cookie quality. As with the multiple regression models of Question 3, we used for this question and for all subsequent questions the Stepwise addition of variables to the model using the statistical program PROC REG in SAS.

**Discussion of Traditional Flour Measures**

Water absorption as measured by the Farinograph was a predictive variable for cookie diameter, height, and shape factor (Table 4). The $R^2$ for models with the Farinograph were similar to the values using just simple measures described in the above section (Table 3). For the height and shape factor measures, water absorption was the only variable that was retained in the model. All other variables were non-significant after water absorption was included in the model. The lower water absorption of a flour sample, the larger and flatter the cookie. As in the previous model (Table 3), flour protein was the best predictor of snapping force to break a cookie; adding Farinograph measures to the model did not improve the prediction of cookie snapping force. When snapping force was standardized by dividing it by the diameter of the cookie, Farinograph stability was the best predictor of cookie texture. As stability increased so did the force to snap the cookie.

Alveograph P was a significant predictor variable for all regression models, predicting all of the cookie quality measures. The regression models for Alveograph were generally more significant than the Farinograph models, with the $R^2$ for cookie diameter predicting 36% of the variation in diameter. Flour samples with smaller Alveograph P values produced cookies that were larger in diameter, thinner and more tender. Alveograph L and W were included in the multiple regression models for cookie diameter and shape factor although these measures were less significant to the total model than Alveograph P. Flour protein was still the most important predictor of cookie texture, with smaller concentrations of flour protein producing more tender cookies.

Alveograph was a better predictor of cookie quality than Farinograph in this study. Can other flour quality measurements improve the prediction of cookie quality?

**Table 5. Prediction of cookie quality based on flour protein and Farinograph measures**

| Cookie characteristic | Prediction model | $R^2$ |
|---|---|---|
| Diameter | 21.5 + 0.207 Flour protein – 0.135 Absorption – 0.115 Stability | 0.23 |
| Height | 6.81 + 0.276 Absorption | 0.13 |
| Shape factor | 1.57 – 0.0157 Absorption | 0.15 |
| Snapping force | 1812 + 69.2 Flour protein | 0.11 |
| Force/Diameter | 289 + 4.66 Stability | 0.06 |

**Table 6. Prediction of cookie quality based on flour protein and Alveograph measures**

| Cookie characteristic | Prediction model | $R^2$ |
|---|---|---|
| Diameter | 18.0 - 0.0482 P - 0.00936 L + 0.00484 W | 0.36 |
| Height | 19.4 + 0.0522 P | 0.16 |
| Shape factor | 0.972 – 0.00556 P – 0.000931 L + 0.0007 W | 0.29 |
| Snapping force | 1429 + 85.2 Flour protein + 6.99 P | 0.13 |
| Force/Diameter | 155 + 11.4 Flour protein + 1.44 P | 0.19 |

***Question 5. What are the relationships of solvent retention capacity (SRC) tests to other quality measures?***

Solvent retention capacity tests are based on certain assumptions of flour functionality. The water SRC is a measure of global water absorption of the flour in much the same way as Farinograph absorption measures flour absorption. Sodium carbonate SRC is a measure of starch damage. Sucrose SRC is a measure of arabinoxylans. Lactic acid SRC is a measure of gluten strength. We did not have a single measure of arabinoxylans in this study. That is conducted in a separate smaller study. However, arabinoxylans contribute to the magnitude of the Alveograph P. Similarly, we do not have a single measure of gluten strength. However, greater flour protein concentration can increase gluten strength. Increased Alveograph W and Farinograph stability measures are considered to be measures that increase as gluten strength increases. Do these assumptions of the solvent retention capacity test hold when looking at a set of varieties milled on a long-flow flour mill? Again, flour protein is included in each of these models as a potential covariate and fit in a stepwise forward model.

**Discussion of Solvent Retention Capacity Tests**

The assumptions of the SRC tests were validated in this data set for water, sucrose, and lactic acid solvents. Flour protein and Farinograph water absorption combined predict half of the variation in water SRC (Table 6). Sucrose SRC measures gliadin hydration and arabinoxylan absorption that contribute to the dough stiffening which elevates Alveograph P. For this set of varieties, flour protein was a more important predictor of sucrose SRC than Alveograph P, but both variables combined for a significant prediction of the solvent's effects. Lactic acid SRC is a measure of the hydration of glutenin macropolymers and gliadins. The other measures of gluten in this study are inter-related to the lactic acid SRC. Farinograph stability and Alveograph W combined to predict nearly half of the variation among the samples for lactic acid SRC.

Damaged starch was not correlated with sodium carbonate SRC. Sodium carbonate SRC was negatively correlated to flour yield ($p<0.01$). The test appears to be measuring milling behavior of the varieties. However, the degree to which starch in flour of soft wheat samples is damaged in the milling process does not appear to relate to the sodium carbonate SRC. This solvent is capturing some other aspect of the mill's effect on flour. This observation is consistent with previous studies of differences among soft wheat varieties.

***Question 6. Does the solvent retention capacity test predict wire-cut cookie quality?***

The solvent retention capacity tests were developed to predict the performance of flour in factory production of commercial soft wheat products such as cookies. The flour is suspended in an excess of the solvent, for example water or 50% sugar, to rapidly determine the optimum amount of water for a cracker or sugar syrup that will be needed to hydrate the flour in a bakery. The affinity of the flour for solvents within the dough will determine the behavior of the dough during machining of the product and baking. Do these tests predict the baking performance of the experimental models?

**Discussion of SRC prediction of cookies.**

The diameter or expansion of the wire-cut cookie is modeled by the Sucrose SRC and the overall water absorption as measured by the Water SRC. Sucrose SRC and Water SRC are the most consistent predictors of cookie quality characteristics, each appearing in three of the five cookie quality parameters measured in this study (Table 7). Flour protein was not an important predictor of cookie shape when SRC solvents are included in the model. Flour protein does appear to increase the hardness of a cookie and was retained as a significant predictor of snapping force in combination with sucrose SRC to predict approximately a third of the variation in cookie texture. Based on the relative sizes of the $R^2$ value, the prediction of cookie quality with solvent retention capacity tests was better than the predictions derived from Alveograph or Farinograph parameters.

**Table 7. Prediction models for solvent retention capacity tests using other quality measures based on the assumptions described above for the solvent retention capacity test**

| Cookie characteristic | Prediction model | $R^2$ |
|---|---|---|
| Water SRC | -0.732 – 0.711 Flour protein + 1.139 Farinograph absorption | 0.53 |
| Sodium carbonate SRC | Neither flour protein nor damaged starch were significant | |
| Sucrose SRC | 67.87 + 1.55 Flour protein + 0.265 P | 0.30 |
| Lactic acid SRC | 73.66 + 1.31 Stability + 0.223 W | 0.45 |

**Table 8. Prediction of cookie quality based on flour protein and solvent retention capacity measures**

| Cookie characteristic | Prediction model | $R^2$ |
|---|---|---|
| Diameter | 23.4 – 0.0266 Sucrose[†]– 0.0968 Water | 0.35 |
| Height | 5.60 + 0.0181 Lactic + 0.0916 Sodium carbonate + 0.140 Water | 0.35 |
| Shape factor | 1.67 - 0.00129 Lactic -+ 0.0149 Water | 0.34 |
| Snapping force | 243 + 54.0 Flour protein + 18.8 Sucrose | 0.19 |
| Force/Diameter | -13.9 + 3.52 Sucrose | 0.23 |

[†]The solvent retention capacity tests are denoted only by their solvent, for example the sucrose SRC test is abbreviated only as ‘Sucrose’.

***Question 7. Does combining solvent retention capacity tests with Alveograph or Farinograph measures improve the prediction of wire-cut cookie quality?***

Farinograph and Alveographs measure in very specific ways flour hydration effects and dough rheology. Solvent retention capacity tests measure a wider range of the flour hydration effects but provide only indirect information about dough rheology because a dough is never developed in the test. The tests often are considered to be correlated to each other as discussed above in the prediction models for the SRC tests (Question 5). Yet, they are measuring flour in different ways and may provide complimentary information about the flour.

**Discussion of combining different test for quality**

Combining the Farinograph information with the solvent retention capacity data did not improve the models. The models were essentially the same as those derived without the Farinograph data. Neither of the Farinograph measures appeared in the multiple regression models. Although Farinograph absorption is an important predictor of cookie shape, the water SRC is a better predictor of the same thing and the Farinograph absorption adds no useful information to the prediction model after water SRC has been added to the system. The minor differences between these models and the models fit with SRC solvents alone were due to the slightly smaller data set used in this analysis because Farinograph data was available only for 112 samples, while the SRC data discussed in Question 6 was available for a larger data set.

The Alveograph measures of P and L in combination with solvent retention capacity tests produce the best multiple regression prediction models for the quality of wire-cut cookies. Water SRC together with Alveograph P and L predict 44% of the variation in cookie diameter. The texture of the cookies as measured by snapping force was best predicted by flour protein, sucrose SRC and either Alveograph P or L, depending on whether the force was corrected or not for final diameter of the cookie.

In this set of samples, Alveograph parameters, flour protein concentration, and solvent retention capacity tests provide complementary information to the prediction of baked product quality.

**Table 9. Prediction of cookie quality based on flour protein, solvent retention capacity and Farinograph measures in 112 samples of soft winter wheat**

| Cookie characteristic | Prediction model | $R^2$ |
|---|---|---|
| Diameter | 23.9– 0.0307 Sucrose[1]– 0.0984 Water | 0.35 |
| Height | 7.79 + 0.042 Sucrose + 0.137 Sodium carbonate | 0.36 |
| Shape factor | 1.74– 0.0365 Sucrose – 0.0124 Water | 0.39 |
| Snapping force | 629 + 19.6 Sucrose | 0.17 |
| Force/Diameter | -3.55 + 3.38 Sucrose | 0.26 |

[1] The solvent retention capacity tests are denoted only by their solvent, for example the sucrose SRC test is abbreviated as ‘Sucrose’.

# Soft Wheat Quality Presentations

## Incorporating important biochemical attributes into breeding programs

**Edward Souza and Mary Guttieri**

A flow chart and recommendations for management of breeding schemes to develop new varieties with desired biochemical components is introduced. Selection priorities, tips on evaluation of assays, crossing plans and when to bail are discussed. This is a breeder's map to addressing incorporation of complex traits.

LINK OUT TO PRESENTATION: **Breeding Biochemical Traits AACCI.pdf**

## Breeding for Fiber Content in Wheat Flour

**Edward Souza, Mary Guttieri, Anne Sturbaum, Clay Sneller and Meera Kweon**

Water extractable arabinoxylans, the dominant fiber component in wheat, is a target for research in milling and baking flour. Characteristic quality tests, such as solvent retention tests (SRCs) and whole wheat bake tests correlate with arabinoxylan configuration in wheat flour. Biochemical and genetic analysis of the arabinoxylans are described and discussed in the context of wheat and fiber quality.

LINK OUT TO PRESENTATION: **Breeding for Fiber Content in Wheat Flour.pdf**

## Soft Wheat and Fiber

**Edward Souza and Mary Guttieri**

High fiber wheat products are increasingly introduced into the U.S. market as a healthy alternative to traditional baked goods. Wheat fiber, methods for measuring fiber, fiber additives and results of cookie bakes with added fibers are presented. Presentation was given at the 2010 Biscuit and Cracker Manufacturers Association meeting.

LINK OUT TO PRESENTATION: **Soft Wheat and Fiber.pdf**

## Soft Red Winter Wheat: Abundant, Flexible, High Quality, Continuous Improvement

**E. Souza and M. Kweon**

A summary of the soft red wheat production and research in the U.S. was presented to Latin American Buyers in 2010. The presentation introduces the research performed at the SWQL with an emphasis on international comparisons of quality requirements.

LINK OUT TO PRESENTATION: **Latin American Buyers Presentation.pdf**

## Steps Necessary for Good Quality Soft Wheat

**E. Souza and Mary Guttieri**

A variety of baking and chemical tests to identify grain characteristics are important to breeders selecting for soft wheat flour and milling quality. The usefulness of these tests, their interrelatedness and outcomes discussed here are relevant to wheat researchers. Targets for quality and major genes affecting quality are reviewed. International and U.S. requirements for wheat quality differ based on product variations, yet a common breeding strategy, summarized here, can be applied to all. Presentation was given to the 2010 Chinese Wheat Genetic Conference in Yangzhou

LINK OUT TO PRESENTATION: **Steps Necessary for Good Soft Wheat.pdf**

## Can Host Plant *Resistance* Protect Quality of Wheat from Fusarium Head Blight?

**Edward Souza[1]*, Nicki Mundell[2], Daniela Sarti[2], Ana Balut[2], Yanhong Dong[3] and Dave Van Sanford[2]**

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Fusarium head blight (FHB) infection reduces the amount of millable grain from an infected field, reduces mill yields, and generally degrades end-use quality. In 2009, the Logan County, KY extension wheat trial had extended conditions for infection with FHB resulting in extensive and uniform infection within the trial. FHB disease incidence and field grain yield were recorded. The trials were harvested and evaluated for percent of millable grain, milling yield and soft wheat quality using standard methods of the American Association of Cereal Chemistry.

Cultivars differed for the amount of grain aspirated during cleaning (Cultivar F-value>22) with Coker 9511 having the smallest loss due to aspiration (3.4% removed) and SS 8641 having the greatest aspiration removal (74.4% removed). Generally the results correlated to known resistance levels with resistant cultivars having fewer scabby or shriveled grains. The percent of aspirated seed was negatively correlated to field yield ($r>-0.25^*$) and test weight ($r>-0.87^{***}$), and was positively correlated to field infection ($r>0.63^{***}$).

Methods: Samples were harvest from a University of Kentucky extension trial in Logan County and lightly cleaned at harvest. At the Soft Wheat Laboratory, four field replications of samples were weighed before and after aspiration; and following aspiration, the four replications were combined to form two replications for milling and baking evaluation. Samples were milled on the Quad Advanced system and evaluated for soft wheat quality using standard AACC approved methods.

To estimate the value of flour produced per hectare in FHB Table 1, the grain yield was multiplied by the percent of un-millable material aspirated from the sample and the product multiplied by the percent of the weight of millable grain recovered as flour.

FHB Table 2 presents additional quality data for the 15 cultivars with the greatest estimated flour yield per hectare. For 12 cultivars representing a cross-section of resistance to Fusarium head blight, a sub-sample of un-aspirated grain also was milled and baked to measure the loss in quality due to the presence of *Fusarium* affected kernels (FHB Table 3).

Conclusions:

- Genetic differences for grain yield, percent millable grain, and flour extraction lead to about a 6X range in the value of genetic improvement (FHB Table 1).
- Except for the highest yielding cultivars, the percent of millable grain varies greatly (FHB Table 1).
- Among the cultivars with the best millable grain yield, ARX 6202, Becks 122, V 9723, and SS 8302 are the best quality cultivars (FHB Table 2).
- Comparing aspirated to unaspirated samples (FHB Table 3) showed that aspiration improved milling yield of the remaining seed and gluten strength (lactic acid SRC).

Selection for Quality and *Fusarium* Resistance
No cultivar x aspiration interaction was found for milling yield. That is, relative flour yield (ranking of genotypes) was approximately the same with or without *Fusarium* affected kernels. Therefore, we should be able to select for milling yield and *Fusarium* resistance in independent trials and pick the lines that will have the best resistance and milling yield in the presence of disease pressure.

**FHB Table 1.**

**Agronomic yield, cleaning yield and flour yield of soft red winter wheat cultivars produced in Logan Co., KY, 2009, under extensive and uniform disease pressure from pathogens causing Fusarium head blight.**

| Variety Name | Grain yield | Test weight | Fraction removed by aspiration | Millable grain | Flour yield | Flour per hectare |
|---|---|---|---|---|---|---|
| | (A) | | (B) | (C) (A x B/100) | (D) | (C x D/100) |
| | kg/ha | $k/m^3$ | % | kg/ha | % | kg/ha |
| Coker 9511 | 4918 | 719 | 3.3 | 4756 | 69.8 | 3317 |
| Truman | 4852 | 705 | 6.9 | 4516 | 69.2 | 3123 |
| Exsegen Dinah | 4754 | 671 | 12.9 | 4138 | 69.2 | 2862 |
| SS 8302 | 4635 | 667 | 14.9 | 3946 | 69.8 | 2752 |
| Pembroke | 4252 | 675 | 11.9 | 3747 | 69.0 | 2585 |
| EXCEL 234 | 3943 | 687 | 11.6 | 3484 | 69.2 | 2411 |
| SS MPV-57 | 4404 | 634 | 21.8 | 3445 | 69.6 | 2396 |
| Dyna-Gro 9911 | 3851 | 683 | 7.5 | 3562 | 67.0 | 2386 |
| Dyna-Gro 9922 | 4680 | 648 | 28.3 | 3357 | 69.6 | 2335 |
| Steyer Jordan | 3740 | 682 | 6.8 | 3483 | 66.9 | 2330 |
| AgriPro W1377 | 3918 | 677 | 12.8 | 3417 | 68.1 | 2327 |
| Beck 122 | 4148 | 624 | 21.7 | 3249 | 70.2 | 2281 |
| Armor ARX 6202 | 4071 | 665 | 22.4 | 3158 | 71.4 | 2253 |
| Bess | 3955 | 653 | 17.8 | 3250 | 68.2 | 2215 |
| Dyna-Gro V9723 | 4086 | 637 | 23.1 | 3140 | 70.0 | 2197 |
| SC 1325 | 3856 | 681 | 17.1 | 3197 | 67.2 | 2147 |
| MO 011126 | 3633 | 641 | 19.5 | 2924 | 72.5 | 2120 |
| SC 1328B | 4727 | 629 | 35.3 | 3060 | 69.2 | 2117 |
| Beck 113 | 4145 | 637 | 22.9 | 3195 | 66.1 | 2112 |
| Pioneer 26R15 | 4487 | 627 | 33.1 | 3003 | 69.6 | 2090 |
| Dyna-Gro V9710 | 3712 | 659 | 16.8 | 3087 | 67.6 | 2087 |
| SS 8404 | 3806 | 642 | 22.5 | 2950 | 70.5 | 2080 |
| Delta King 9108 | 3759 | 628 | 23.6 | 2873 | 70.7 | 2030 |
| Dixie 940 | 3999 | 628 | 27.7 | 2890 | 70.2 | 2029 |
| Pioneer 25R63 | 3835 | 620 | 24.4 | 2900 | 69.3 | 2008 |
| AgriPro Branson | 3759 | 630 | 24.5 | 2840 | 70.0 | 1988 |
| SC 1298 | 3868 | 626 | 26.6 | 2839 | 69.8 | 1980 |
| Clark | 3192 | 667 | 8.8 | 2909 | 67.5 | 1964 |
| Exsegen Anna | 4015 | 591 | 31.1 | 2767 | 69.1 | 1912 |
| Cumberland | 3553 | 648 | 21.7 | 2781 | 67.1 | 1866 |
| Pioneer 26R22 | 3698 | 630 | 29.2 | 2617 | 71.2 | 1863 |
| Jamestown | 3015 | 690 | 12.4 | 2640 | 66.9 | 1765 |

| Variety Name | Grain yield | Test weight | Fraction removed by aspiration | Millable grain | Flour yield | Flour per hectare |
|---|---|---|---|---|---|---|
| Exsegen Candace | 3522 | 625 | 29.7 | 2476 | 70.1 | 1735 |
| Steyer Geary | 3812 | 595 | 33.0 | 2553 | 66.8 | 1704 |
| Dixie 989 | 3891 | 641 | 36.7 | 2461 | 69.1 | 1700 |
| SS 548 | 3535 | 625 | 30.7 | 2450 | 69.0 | 1691 |
| Armor 360Z | 3647 | 631 | 33.4 | 2429 | 69.4 | 1685 |
| SS 8309 | 3738 | 625 | 36.3 | 2382 | 70.4 | 1677 |
| USG 3350 | 3866 | 630 | 37.8 | 2404 | 69.7 | 1674 |
| SS 5205 | 3360 | 631 | 27.8 | 2425 | 68.3 | 1656 |
| Pioneer 25R78 | 3459 | 640 | 31.6 | 2365 | 69.9 | 1653 |
| Steyer Nofzinger | 3925 | 593 | 40.2 | 2347 | 69.9 | 1639 |
| Red Ruby | 3714 | 617 | 36.8 | 2347 | 69.5 | 1630 |
| Armor ARX 840 | 3649 | 613 | 34.2 | 2403 | 67.2 | 1613 |
| SC 1339 | 3766 | 607 | 36.5 | 2390 | 66.9 | 1597 |
| SC 1318 | 3816 | 613 | 39.7 | 2302 | 69.4 | 1597 |
| Delta Grow 4500 | 3926 | 624 | 43.1 | 2232 | 69.5 | 1550 |
| Dyna-Gro V9812 | 3845 | 620 | 42.0 | 2230 | 69.3 | 1544 |
| Delta King 9577 | 3186 | 634 | 32.6 | 2146 | 69.8 | 1498 |
| Exsegen Lydia | 3191 | 610 | 35.7 | 2052 | 68.3 | 1401 |
| Dixie 907 | 4200 | 615 | 51.9 | 2019 | 69.2 | 1396 |
| SC 1348 | 4063 | 612 | 50.3 | 2019 | 68.7 | 1386 |
| Dyna-Gro Shirley | 3980 | 588 | 51.1 | 1946 | 69.3 | 1349 |
| Delta Grow 1600 | 3825 | 615 | 51.4 | 1858 | 69.5 | 1291 |
| EXCEL 341 | 4167 | 611 | 55.9 | 1837 | 69.1 | 1269 |
| SS 520 | 2880 | 608 | 38.0 | 1785 | 69.3 | 1236 |
| Exsegen Lois | 4195 | 585 | 56.9 | 1809 | 67.1 | 1214 |
| Delta Grow 5200 | 3818 | 610 | 59.5 | 1547 | 69.8 | 1079 |
| Armor Gold | 2504 | 612 | 37.4 | 1568 | 68.3 | 1071 |
| SS 8641 | 3156 | 554 | 74.4 | 807 | 69.8 | 563 |
| Standard error | | | 3.29 | | 0.6 | |
| F-value for cultivars | | | 22.6*** | | 4.76*** | |
| $R^2$ for Rep and Cultivar | | | 88.50% | | 82.6% | |

**FHB Table 2.**

**Milling and baking quality of the a selection of high-yield and Fusarium resistant soft red winter wheat cultivars, Logan Co. KY, 2009.**

| | Flour yield | Softness equivalent | Flour protein | Lactic acid | Sucrose SRC | Cookie diameter |
|---|---|---|---|---|---|---|
| | % | % | % | % | % | cm |
| AgriPro W1377 | 68.1 | 63.5 | 8.44 | 112.3 | 98.2 | 18.04 |
| Armor ARX 6202 | 71.4 | 66.7 | 8.81 | 106.8 | 91.3 | 19.55 |
| Beck 122 | 70.2 | 68.4 | 7.95 | 101.7 | 93.4 | 19.40 |
| Bess | 68.2 | 64.6 | 8.41 | 97.5 | 94.3 | 19.13 |
| Coker 9511 | 69.8 | 59.0 | 9.13 | 105.4 | 91.2 | 19.01 |
| Dyna-Gro 9911 | 67.0 | 58.4 | 8.69 | 102.3 | 97.3 | 18.80 |
| Dyna-Gro 9922 | 69.6 | 69.5 | 8.03 | 112.1 | 93.0 | 19.53 |
| Dyna-Gro V9723 | 70.0 | 67.5 | 8.18 | 100.5 | 89.4 | 19.27 |
| Excel 234 | 69.2 | 64.3 | 8.40 | 106.5 | 91.5 | 19.50 |
| Exsegen Dinah | 69.2 | 64.4 | 8.70 | 116.6 | 92.8 | 19.34 |
| Pembroke | 69.0 | 64.9 | 9.42 | 111.1 | 99.7 | 18.92 |
| SS 8302 | 69.8 | 67.8 | 8.81 | 116.9 | 98.2 | 18.95 |
| SS MPV-57 | 69.6 | 61.2 | 8.93 | 89.2 | 91.6 | 19.20 |
| Steyer Jordan | 66.9 | 56.9 | 9.00 | 102.8 | 96.6 | 18.81 |
| Truman | 69.2 | 62.6 | 8.10 | 113.1 | 92.7 | 19.10 |

**FHB Table 3.**

**Comparison of milling and baking quality from samples that were processed as received after coarse cleaning and samples that were extensively aspirated to remove tombstone and other un-millable seed, Logan Co. Trial, KY, 2009.**

| | Milling yield | | Cookie diameter | | Lactic acid SRC | |
|---|---|---|---|---|---|---|
| | Clean | Not cleaned | Clean | Not cleaned | Clean | Not cleaned |
| | % | % | cm | cm | % | % |
| AgriPro Branson | 70.0 | 69.4 | 19.3 | 19.1 | 108.9 | 103.3 |
| AgriPro COKER 9511 | 69.8 | 69.2 | 19.0 | 19.2 | 105.4 | 106.4 |
| Beck 122 | 70.2 | 69.5 | 19.4 | 19.0 | 101.7 | 99.6 |
| Bess | 68.2 | 67.3 | 19.1 | 19.3 | 97.5 | 95.9 |
| Clark | 67.5 | 67.1 | 18.9 | 19.1 | 94.0 | 90.8 |
| Cumberland | 67.1 | 66.3 | 18.5 | 18.6 | 101.6 | 95.7 |
| Jamestown | 66.9 | 66.7 | 18.1 | 18.1 | 116.0 | 109.2 |
| Pembroke | 69.0 | 69.1 | 18.9 | 18.9 | 111.1 | 113.7 |
| SS 520 | 69.3 | 68.3 | 18.9 | 18.8 | 97.4 | 86.8 |
| SS 5205 | 68.3 | 67.2 | 19.5 | 19.4 | 111.5 | 111.0 |
| SS MPV-57 | 69.6 | 68.8 | 19.2 | 19.4 | 89.2 | 81.7 |
| Truman | 69.2 | 68.5 | 19.1 | 19.5 | 113.1 | 111.3 |
| Average | 68.7 | 68.1 | 19.0 | 19.0 | 103.9 | 100.4 |
| Standard error | 0.3 | 0.3 | 0.2 | 0.2 | 1.8 | 1.8 |
| F-test of genotype by aspiration effect | $0.56^{ns}$ | | $0.88^{ns}$ | | 2.4* | |

# Basis for Selecting Soft Wheat for End-Use Quality

Edward J. Souza, Clay Sneller, Mary J. Guttieri, Anne Sturbaum, Carl Griffey, Mark Sorrells, Herbert Ohm, and David Van Sanford.

**Summary**
Selection to improve milling and baking quality of soft wheat should be highly effective based on the observed genetic variation in this study and the relatively small genotype by environment interactions for most traits, other than test weight.
The USDA-ARS Soft Wheat Quality Laboratory recommends focus on a limited number of quality traits that are both heritable and relatively easy to measure on large numbers of samples. Selection to maintaining a quality type could be more efficient by emphasizing a limited number of traits with large heritability values. Flour yield, softness equivalent, and sucrose SRC represent different components of quality that have favorable genetic and phenotypic correlations (Table 11). These traits are commonly measured using short flow experimental mills, such as the modified Quadrumat mill, yet they also have good correlations to long-flow milling quality valued in commercial production (Table 13). Emphasizing these traits could quickly identify unacceptable genetic combinations in breeding materials and allow programs to focus on traits of value to seed dealers and farmers who will be the first customers for the improved cultivars.

This study does not support placing a significant emphasis on selection for test weight due to its low heritability and limited predictive value for the more important trait of milling yield. We found a small positive correlation in plot to plot variation between test weight and milling yield but the two traits have a small negative correlation with each other among means of genotypes. The current wheat grading and discount system hinders production of cultivars having excellent milling and baking quality but lower inherent test weight. Selection for test weight may be necessary for grain grading purposes, but it does not appear to be useful in selecting genotypes with improved milling yield.

Early in the 20$^{th}$ century, the introduction of standard baking methods, such as the sugar snap cookie, quickly identified and eliminated from soft winter production the cultivars that were true hard wheat genotypes or harder endosperm soft wheat genotypes. Through time cultivars have been selected to have smaller flour protein concentration and weaker gluten as measured by lactic acid SRC. However, after factoring out the protein decline, gluten strength per unit of protein has actually increased over time. Breeders have maintained a diversity of gluten types, both strong and weak. This variability among cultivars is valuable given the diversity of gluten requirements by end-users of eastern US soft wheat. Most striking in the study is that concurrent with dramatic increases in grain yield and disease resistance, plant breeders have maintained through selection the target quality of the soft wheat market class and perhaps made incremental improvements.

Previous work (see millstream poster attached to annual report) found that both gluten strength and arabinoxylan concentration are directly tied to the total flour extraction rates on long flow flour mills and to the rate of flour recovery in the early reduction rolls, which in turn influences other quality characteristics such as starch damaged by milling. The large genetic variances for flour quality and milling characteristic and their correlations among genotypes suggest that the soft wheat quality traits measured in this study have common underlying genetic control. Traits as complex as milling yield might be modeled based on relatively well characterized genes such as the glutenins, among others. Genetic systems, such as non-starch polysaccharide synthesis, are rapidly yielding to genomic analysis and also could contribute to milling traits. Mapping genes in these pathways should identify loci that affect multiple quality attributes. Candidate gene analysis should be pursued to identify alleles with large effects on the wheat quality phenotype and those that will be useful as molecular markers in breeding.

**Materials and Methods**

A stratified selection of soft red and soft white winter wheat cultivars and several advanced breeding lines were selected by the authors based on three criteria: 1) the genotype had been previously evaluated by the SWQL for milling and baking quality using the long-flow Allis milling system (Souza et al. 2008), 2) seed that had been produced at least once by the authors or the previous directors of the SWQL (Souza et al. 2010) and was available for the study, and 3) the genotypes represented important variation in the crop based on a) area of production in eastern North America, b) use as a breeding parent, or c) milling and baking performance within the SWQL Allis milling evaluation. Importance of older lines (before 1930) was based primarily on Clark and Bales (1935). Lines were included for one or more of the above reasons and the final list was based on the expertise of the authors. Seed was provided to all cooperators by the wheat breeding program at the Ohio State University. A complete association mapping cultivar list is attached and can be found on the SWQL website.

Cultivars were produced in standard 7-row yield test plots using seeding rates, planting dates, and harvest times recommended and appropriate for the local growing conditions. A non-replicated field design was used with the soft red winter wheat cultivars Roane and Foster randomly replicated within the trial to estimate within field variances. The trials were planted in fall 2006 at Warsaw, Virginia, Ithaca, New York, West Lafayette, Indiana, and Wooster, Ohio. Plots were harvested in 2007 using small plot combines. The same genotypes were planted at the same locations in fall 2007 with an additional site at Lexington, Kentucky, and all plots were harvested the following summer. Weeds were controlled at each location with appropriate broadleaf herbicides. Aphids were controlled with labeled applications of pesticides in 2008 at the Warsaw, VA location.

New York, Ohio, and Virginia provided a minimum of a 250 gram grain sample from each plot to the SWQL for evaluation. Indiana and Kentucky provided a minimum of 100 grams. Samples were aspirated to remove foreign material and non-millable grain. Samples were tempered and milled on a modified Quadrumat milling system as described by Finney and Andrews (1986). Flour protein concentration was determined on flour using near infra-red reflectance (Unity Spectra-Star 2200, Columbia, MD) with supporting values provided by the Dumas method (AACC approved method AACC Method 46-19.01, 2010) of combustion nitrogen analysis (Elementar Nitrogen Combustion Analyzer, Elementar America, Mt. Laurel, NJ). Water, lactic acid, and sodium carbonate solvent retention capacity (SRC) was used to measure the suitability of flour for use in soft wheat products on 1 g samples of flour (modification of AACC method 56-11.02, 2010). Sucrose SRC was measured on a 5 g sample of flour as per AACC method 56-11.02. A summary ratio was calculated from the individual solvents of the 56-11.02 method: for each sample the lactic acid SRC value was divided by the sum of the sodium carbonate SRC value and the sucrose SRC value. The SRC ratio estimates the functionality of the water binding capacity of flour: water binding due to gluten strength for leavening and expansion of dough during baking is necessary, but water binding due to damaged starch and water soluble arabinoxylans typically does not contribute to desirable dough rheology and lengthens baking time, leading to more brittle baked products. Samples from the trials in New York, Ohio, and Virginia were evaluated using the sugar-snap cookie method (AACC Method 10-52.02). The combined diameter of two cookies was measured for each sample and a visual assessment of the top-grain, surface cracking was scored from 0 to 9, with 0 having no surface expansion cracks (undesirable) and 9 having extensive surface expansion cracks (desirable).

**Aknowledgements**
The authors wish to acknowledge the funding of the Cooperative State Research, Education, and Extension Service (USDA-CSREES), National Research Initiative, CAP grant number 2006-55606-16629, USDA Agricultural Research Service, National Program 306, and Kraft Foods. The results of this work would not be possible without the skill and work of the Soft Wheat Quality staff, including Amy Bugaj and Tom Donelson, and the Ohio State University staff of Sue Carson, Duc Hua, and Sharon Croskey.

**References**

American Association of Cereal Chemists (AACC). 2010. Approved methods of the AACC, 10th edition. The Association, St. Paul, MN.

Clark, J.A. and B.B. Bayles. 1935. Classification of wheat varieties grown in the United States. United States Department of Agriculture, Technical Bulletin No. 459. 164 pages. Washington D.C.

Finney P.L., and L.C. Andrews. 1986. Revised microtesting for soft wheat quality evaluation. Cereal Chem. 63:177-182.

Souza, E.J., C. Griffey, M. Kweon, and M.J. Guttieri. 2008. Sources of variation for long-flow milling. Crop Sci. 48:1432-1440.

Souza, E. M. Kweon and A. Sturbaum. 2010. Summary of Research Results for the Soft Wheat Quality Laboratory, USDA-ARS. Soft Wheat Quality Laboratory Research Review Conference, March 10, 2010 SWQL website.

**Table 10. Analysis of variance for soft wheat grain and flour quality measured in an association mapping population grown at 4 environments (Env) in 2007 and 5 environments in 2008, with milling and flour analyses at all environments and cookie baking evaluations in 3 environments in each year.**

| Trait | Type III Mean Squares | | | | Variance components (VC)† | | VC Ratios‡ | |
|---|---|---|---|---|---|---|---|---|
| | Env | Cultivar | Cultivar x Env | Error | Env | Genotype | $VC_e$/ $VC_g$ | $VC_{gxe}$/ $VC_g$ |
| D.F. | 8 | 186 | 1477 | 73 | | | | |
| Test weight | 1803.6*** | 19.8*** | 2.07*** | 0.54 | 9.652 | 2.071 | 4.660 | 0.739 |
| Flour protein | 99.13*** | 3.67*** | 0.20*** | 0.06 | 0.528 | 0.366 | 1.443 | 0.383 |
| Flour yield | 296.4*** | 20.34*** | 0.93*** | 0.18 | 1.577 | 2.063 | 0.764 | 0.363 |
| Softness equiv. | 1008.6*** | 107.5*** | 4.36*** | 0.85 | 5.357 | 10.975 | 0.488 | 0.320 |
| Water SRC | 253.1*** | 29.54*** | 1.46*** | 0.64 | 1.340 | 2.944 | 0.455 | 0.279 |
| $Na_2CO_3$ SRC | 428.8*** | 71.39*** | 3.26*** | 1.03 | 2.266 | 7.200 | 0.315 | 0.310 |
| Sucrose SRC | 3745.71*** | 252.55*** | 10.09*** | 6.16 | 19.912 | 25.354 | 0.785 | 0.155 |
| Lactic acid SRC | 32602*** | 1422.21*** | 52.84*** | 20.3 | 173.678 | 144.750 | 1.200 | 0.225 |
| SRC Ratio(?) | 0.8364*** | 0.0362*** | 0.0016*** | 0.0006 | 0.004 | 0.006 | 0.770 | 0.171 |
| D.F. | 5 | 186 | 920 | 47 | | | | |
| Cookie diameter | 64.7*** | 5.14*** | 1.20 | 0.86 | 0.3 | 0.5 | 0.68 | 0.68 |
| Cookie top-grain | 75.47*** | 5.99*** | 1.39 | 0.86 | 0.4 | 0.6 | 0.65 | 0.88 |

*** - F-value significant at $p < 0.001$.

† VC – Variance components for source of variation in the analysis of variance

‡ $VC_e$- variance component term attributed to environment, $VC_g$ – variance component term attributed to genotype, $VC_{gxe}$ – variance component term attributed to genotype x environment interaction.

**Table 11. Correlation matrix (r values) for milling and baking traits measured on 187 cultivars in 9 environments, 2007 to 2008; are correlations of genotypic averages (n=187).**

| | Test Weight | Flour Yield | Softness Equivalent | Flour Protein | Water SRC | Sodium carbonate SRC | Sucrose SRC | Lactic acid SRC | SRC Ratio | Cookie Diameter |
|---|---|---|---|---|---|---|---|---|---|---|
| Test weight | - | | | | | | | | | |
| Flour yield | (-0.051)† | - | | | | | | | | |
| Softness equiv. | -0.288 | 0.233 | - | | | | | | | |
| Flour protein | 0.364 | -0.325 | -0.668 | - | | | | | | |
| Water SRC | 0.406 | -0.512 | -0.415 | 0.268 | - | | | | | |
| Sodium carb. SRC | 0.218 | -0.449 | 0.213 | (-0.094) | 0.691 | - | | | | |
| Sucrose SRC | 0.365 | -0.550 | (-0.103) | 0.334 | 0.720 | 0.748 | - | | | |
| Lactic acid SRC | 0.428 | -0.331 | (-0.118) | 0.465 | 0.395 | 0.367 | 0.688 | - | | |
| SRC ratio | 0.356 | (-0.113) | (-0.143) | 0.462 | 0.093 | (-0.007) | 0.339 | 0.911 | - | |
| Cookie diameter | -0.380 | 0.549 | 0.545 | -0.662 | -0.722 | -0.439 | -0.682 | -0.548 | -0.339 | - |
| Cookie top grain | -0.365 | 0.536 | 0.416 | -0.659 | -0.552 | -0.365 | -0.631 | -0.543 | -0.364 | 0.886 |

†Correlation values in parentheses are not significant (p>0.05). All other values are significantly different from zero (p<0.05).

**Table 12. Extreme genotypes for milling and baking characteristics of soft winter wheat, averaged across nine environments, 2007 and 2008.**

| | Five cultivars with the largest value | | Five cultivars with the smallest value | |
|---|---|---|---|---|
| Milling or baking trait | Average of 5 largest values | Names | Average of the 5 smallest values | Names |
| Test weight | 824.4 kg $m^{-3}$ | Brandy, Coker 68-15, Moking, Royal, Tribute | 746.4 kg $m^{-3}$ | Augusta, Chelsea, Delaware, Houser, Vermont Winter Reeds |
| Flour yield | 73.8 g 100 $g^{-1}$ | Foster, Kristy, Pioneer 26R46, Severn, White Wonder | 67.2 g 100 $g^{-1}$ | Fairfield, Lewis, Longberry No. 1, Mediterranean, Wakeland |
| Softness equivalent | 65.1 g 100 $g^{-1}$ | Boone, Houser, INW 0303, Wisdom, Wonder | 50.2 g 100 $g^{-1}$ | Baldrock, Illini Chief, Kristy, McNair 701, Stoddard |
| Flour protein | 10.9 g 100 $g^{-1}$ | Baldrock, Key, Mediterranean, Sullivan, Wakeland | 8.3 g 100 $g^{-1}$ | Houser, Mitchell, Pioneer 25R47, Tyler, Wilson |
| Water SRC | 55.7 g 100 $g^{-1}$ | Kristy, Mediterranean, Tribute, USG 3209, Wakeland | 48.5 g 100 $g^{-1}$ | Augusta, Caledonia, Daisy, Glacier, Pioneer 25R47 |
| Sodium carbonate SRC | 74.3 g 100 $g^{-1}$ | Blazer, INW 0303, Pioneer 2568, Pioneer 25R37, USG 3209 | 61.9 g 100 $g^{-1}$ | Augusta, FFR 555W, Mallard, Neuse NC, Scotty |
| Sucrose SRC | 105.0 g 100 $g^{-1}$ | Blazer, Harvest Queen, INW 0303, Jackson, USG 3209 | 84.3 g 100 $g^{-1}$ | Augusta, AC Mountain, Caledonia, Honor, Houser |
| Lactic acid SRC | 142.8 g 100 $g^{-1}$ | Blazer, Coker 9134, Key, Wakeland, Warwick | 86.3 g 100 $g^{-1}$ | Grandprize, Hillsdale, Honor, Pioneer 2510, Rupert Giant |

| Table 12. (Continued). | | | | |
|---|---|---|---|---|
| | Five cultivars with the largest value | | Five cultivars with the smallest value | |
| Milling or baking trait | Average of 5 largest values | Names | Average of the 5 smallest values | Names |
| SRC Ratio | 0.857 | Flint, Key, Magnum, Monon, Wakeland | 0.558 | Grandprize, MPV 57, Pioneer 2510, Pioneer 25W60, Rupert Giant |
| Cookie diameter | 18.71 cm | Caledonia, Glacier, Pioneer 2555, Pioneer 25R47, Wonder | 16.58 cm | Key, Kristy, Mediterranean, Rudy, Wakeland |
| Cookie top-grain | 5.45 | Boone, Caldwell, Glacier, Pioneer 2555, Pioneer 25R47 | 1.74 | Forward, Key, Mediterranean, Rudy, Wakeland |

**Table 13. Correlations of Allis mill database values to measured values from micro milling, averaged across all locations, 2007 and 2008.**

| Allis Measurements | Correlation coefficient (r) | Micro milling parameter |
|---|---|---|
| Test weight | 0.72*** | Test weight |
| | | |
| Straight grade flour yield | 0.76*** | Flour yield |
| Endosperm separation index | -0.77*** | Flour yield |
| Friability | 0.78*** | Flour yield |
| | | |
| Break flour | 0.78*** | Softness equivalent |
| | 0.25** | Sodium carbonate SRC |
| | 0.32*** | Cookie diameter |
| | -0.41** | Flour protein |
| | | |
| Cookie diameter | 0.60*** | Cookie diameter |
| | 0.37*** | Softness equivalent |
| | -0.60*** | Water SRC |
| | -0.34*** | Sodium carbonate SRC |
| | -0.46*** | Sucrose SRC |
| | -0.24** | Lactic acid SRC |

** - Correlation coefficient significant at p <0.01.
*** - Correlation coefficient significant at p <0.001.

**Table 14. Change in milling and baking quality through time in 187 cultivars released from 1800 to 2005 as measured using the short-flow, modified Quadrumat milling system in nine environments, 2007 and 2008 and reported in the Allis-Chalmers Flour Mill Database of long-flow flour milling maintained by the USDA SWQL, Wooster, OH.**

| Response Quality | Rate of Change 1801 to 2005 | | Rate of Change 1971 to 2005 | |
|---|---|---|---|---|
| Modified Quadrumat Milling | | | | |
| Flour yield | 0.0079 +/- 0.0026 g 100 $g^{-1}$ $y^{-1}$ | ** | 0.0347 +/- 0.0123 g 100 $g^{-1}$ $y^{-1}$ | ** |
| Softness equivalent | 0.0295 +/- 0.0062 g 100 $g^{-1}$ $y^{-1}$ | *** | 0.0749 +/- 0.0288 g 100 $g^{-1}$ $y^{-1}$ | * |
| Flour protein | -0.0092 +/- 0.0010 g 100 $g^{-1}$ $y^{-1}$ | *** | -0.0274 +/- 0.0043 g 100 $g^{-1}$ $y^{-1}$ | *** |
| Water SRC | -0.0084 +/- 0.0033 g 100 $g^{-1}$ $y^{-1}$ | * | Not significant | |
| Sucrose SRC | -0.0281 +/- 0.0097 g 100 $g^{-1}$ $y^{-1}$ | ** | Not significant | |
| Lactic acid SRC | -0.0491 +/- 0.0237 g 100 $g^{-1}$ $y^{-1}$ | * | -0.273 +/- 0.107 g 100 $g^{-1}$ $y^{-1}$ | ** |
| SRC Ratio | Not significant | | -0.00152 +/- 0.00054 $y^{-1}$ | ** |
| Cookie diameter | 0.0051 +/- 0.0008 cm $y^{-1}$ | *** | 0.0109 +/- 0.0038 cm $y^{-1}$ | ** |
| Top grain | 0.0100 +/- 0.0016 score $y^{-1}$ | *** | 0.0269 +/- 0.0073 score $y^{-1}$ | *** |
| Allis-Chalmers Database | | | | |
| Allis test weight | -0.0116 +/- 0.0022 kg $m^{-3}$ $y^{-1}$ | *** | Not significant | |
| Allis flour protein | -0.0127 +/- 0.0015 g 100 $g^{-1}$ $y^{-1}$ | *** | -0.0337 +/- 0.0059 g 100 $g^{-1}$ $y^{-1}$ | *** |
| Allis friability | 0.0095 +/- 0.0025 g 100 $g^{-1}$ $y^{-1}$ | ** | 0.0232 +/- 0.0113 g 100 $g^{-1}$ $y^{-1}$ | * |
| Allis break flour yield | 0.0199 +/- 0.0064 g 100 $g^{-1}$ $y^{-1}$ | ** | Not significant | |
| Allis cookie diameter | 0.0038 +/- 0.0007 cm $y^{-1}$ | *** | Not significant | |

* Regression coefficient significant at p<0.05.
** Regression coefficient significant at p<0.01.
*** Regression coefficient significant at p<0.001

# Genotypes for varieties evaluated for the Wheat Quality Council (WQC) and Overseas Varietal Analysis (OVA) 2006-2010.

Genotyping was performed at the Soft Wheat Quality Lab and the Regional Small Grains Genotyping Laboratory in Raleigh, N.C. on varieties submitted to the laboratory for milling and baking analysis since 2006. Genotypes for WQC varieties are included since 2006 and for OVA varieties since 2009. The laboratory continues to add new markers to its repertoire for evaluation, blanks in the cells represent "not tested" for varieties genotyped prior to incorporating the marker into our studies.

Important markers associated with dough quality are the high molecular weight glutenins at loci on chromosomes 1A, 1B and 1D (HMW *GluA1*, *GluB1* and *GluD1*), γ-gliadin markers for *GliD1.1* and *GliD1.2* alleles, 1B/1R and 1A/1R rye translocations, and starch synthesis (GBSS) alleles *Wx-A1, Wx-B1*, and *Wx-D1* to indicate waxy nature. *Viviparous-1* transcription factor is implicated in tolerance to pre-harvest sprouting by the 569 allele. A translocation on chromosome 2B confers stem rust resistance via the *Sr36* gene, and semi-dwarfing genes for *Rht1, Rht2* and *Rht8* are markers for plant height. The semi-dominant *Photperiod-D1a* (Ppd-D1a) allele confers photoperiod insensitivity in wheat, allowing early flowering, and three loci (*Fhb1*, *Ernie* on 5AS and *Ning7840* on 5AS) recognize QTL for Fusarium head blight resistance. Primers for PCR reactions, conditions and references for the source of the reactions used at the Soft Wheat Quality laboratory are listed in the Materials and Methods "Genotyping" section of this document. For information on genotyping at the Regional Small Grains Genotyping Laboratory in Raliegh, N.C. please see the website: http://afrsweb.usda.gov/Main/docs.htm?docid=19522.

**Table 15. Genotypes for varieties evaluated for the WQC and the OVA 2006-2010.**

| *Cultivar Name* | *Reference* | *HMW GluA1* | *HMW GluB1* | *HMW GluD1* | *Gamma Gliadin* | *Rye Translocation* | *Waxy* | *Vp1 Pre Harvest Sprout* | *Sr 36 Rust Res* | *Dwarfing Rht1,2,8* | *Photo-period Ppd D1a* | *FHB Resistance* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *AGS 2000* | *WQC07* | *Ax2** | *Not By8,9* | *5+10* | *GliD1.1* | *1BS/1BL* | *WT* | - | - | - | - | - |
| *AGS2060* | *WQC06* | *Ax2** | *Not By8,9* | *5+10* | *GliD1.1* | *NO* | *WT* | - | - | - | - | - |
| *Ambassador* | *WQC10* | *Ax1* | *Bx7oe* | *2+12* | *GliD1.1* | *NO* | *WT* | *650-700* | *NO* | *Rht 2* | *D1a* | *NO* |
| *Amber* | *WQC08* | *Ax1* | *Bx7oe* | *5+10* | *GliD1.1* | *NO* | *WT* | *569* | - | - | - | - |
| *Arcadia* | *WQC10* | *Ax2** | *By8* | *2+12* | *GliD1.1* | *NO* | *WT* | *650-700* | *Sr36* | *Rht 2* | *D1a* | *NO* |
| *Baldwin* | *OVA10* | *Ax2** | *Bx7oe* | *5+10* | *GliD1.1* | *1BS/1BL* | *WT* | *650-700* | *NO* | *Rht 2* | *NO* | *NO* |
| *Beretta* | *WQC09* | *Ax2** | *Not By8,9* | *5+10* | *GliD1.2* | *NO* | *WT* | *650-700* | *NO* | *Rht 1* | *NO* | *NO* |
| *Bess* | *WQC09* | *Ax1* | *By8* | *2+12* | *GliD1.1* | *NO* | *WT* | *650-700* | *NO* | *Rht 1* | *NO* | *NO* |
| *Branson* | *WQC09* | *Ax2** | *Not Bx7oe* | *2+12* | *GliD1.1* | *NO* | *WT* | *650-700* | *NO* | *Rht 1* | *D1a* | *NO* |
| *Caledonia* | *WQC10* | *Ax1* | *By9* | *2+12* | *GliD1.1* | *NO* | *WT* | *650-700* | *NO* | *Rht 2* | *NO* | *NO* |
| *Caledonia Reselect-L* | *WQC07* | *Ax1/Ax2** | *By9* | *2+12* | *GliD1.1* | *NO* | *WT* | - | - | - | - | - |

| Cultivar Name | Reference | HMW GluA1 | HMW GluB1 | HMW GluD1 | Gamma Gliadin | Rye Translocation | Waxy | Vp1 Pre Harvest Sprout | Sr 36 Rust Res | Dwarfing Rht1,2,8 | Photo-period Ppd D1a | FHB Resistance |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Coker9553 | OVA10 | Ax1/Ax2* | By8 | 2+12 | GliD1.1 | NO | WT | 569 | NO | Rht 2 | D1a | NO |
| Coker9804 | WQC09 | Ax1 | Not Bx7oe | 2+12 | GliD1.1 | NO | WT | 569 | NO | Rht 2 | D1a | 5AS-Ernie |
| Coral | WQC08 | Ax1 | By9 | 2+12 | GliD1.1 | NO | WT | 650-700 | - | - | - | - |
| Crystal | WQC07 | Ax1 | Bx7oe | 2+12 | GliD1.1 | NO | WT | - | - | - | - | - |
| D02-8486 | WQC06 | Ax2* | By8 | 2+12 | GliD1.1 | NO | WT | - | - | - | - | - |
| D8006 | WQC07 | Ax1 | Bx7oe | 5+10 | GliD1.1 | NO | WT | - | - | - | - | - |
| D8006W | WQC08 | Ax1 | Bx7oe | 5+10 | GliD1.1 | NO | WT | 569 | - | - | - | - |
| DK9577 | OVA10 | Ax1 | By8 | 2+12/5+10 | GliD1.1 | NO | WT | 569 | NO | Rht 2 | D1a | NO |
| Dominion | WQC09 | Ax2* | Not Bx7oe | 2+12 | GliD1.1 | 1RS/1AL | WT | 569 | Sr36 | Rht 2 | NO | NO |
| E5011B | WQC10 | Ax2* | By9 | 2+12 | GliD1.1 | NO | WT | 650-700 | NO | Rht 2 | NO | NO |
| E5024 | WQC10 | Ax1 | By8 | 5+10 | GliD1.1 | 1BS/1BL | WT | 569 | NO | Rht 2 | D1a | 5AS-Ernie |
| Envoy | WQC08 | Ax1 | Not By8,9 | 2+12 | GliD1.1 | NO | WT | 569 | - | - | - | - |
| GA-96693-4E16 | WQC07 | Ax1 | Not By8,9 | 2+12 | GliD1.1 | 1BS/1BL | WT | - | - | - | - | - |

| Cultivar Name | Reference | HMW GluA1 | HMW GluB1 | HMW GluD1 | Gamma Gliadin | Rye Translocation | Waxy | Vp1 Pre Harvest Sprout | Sr 36 Rust Res | Dwarfing Rht1,2,8 | Photo-period Ppd D1a | FHB Resistance |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Hopewell* | *WQC08* | *Ax1* | *Not By8,9* | *2+12* | *GliD1.1* | *NO* | *WT* | *650-700* | - | - | - | - |
| *Jamestown* | *OVA10* | *Ax2** | *Not By8,9* | *2+12* | *GliD1.1* | *NO* | *WT* | *569* | *NO* | *Rht 2* | *D1a* | *NO* |
| *Jensen* | *WQC09* | *Ax1* | *By9* | *2+12* | *GliD1.1* | *NO* | *WT* | *650-700* | *NO* | *Rht 2* | *NO* | *NO* |
| *Jewel* | *WQC07* | *Ax2** | *Bx7oe* | *2+12* | *GliD1.1* | *NO* | *WT* | - | - | - | - | - |
| *Magnolia* | *WQC09* | *Ax2** | *Not By8,9* | *5+10* | *GliD1.2* | *NO* | *WT* | *650-700* | *NO* | *Rht 1* | *NO* | *NO* |
| *Malabar* | *OVA10* | *Ax1* | *By9* | *2+12/5+10* | *GliD1.1* | *NO* | *WT* | *569* | *NO* | *Rht 1* | *NO* | *5AS-Ernie* |
| *Merl* | *OVA10* | *Ax1* | *By8* | *2+12* | *GliD1.1* | *NO* | *WT* | *650-700* | *NO* | *Rht 2* | *D1a* | *NO* |
| *Merl.1* | *WQC09* | *Ax1* | *Not Bx7oe* | *2+12* | *GliD1.1* | *1BS/1BL* | *WT* | *650-700* | *NO* | *Rht 2* | *D1a* | *NO* |
| *MO 11126* | *WQC08* | *Ax1* | *Bx7oe* | *2+12* | *GliD1.1* | *NO* | *WT* | *650-700* | - | - | - | - |
| *MPG7921* | *WQC06* | *Ax1/Ax2** | *Not By8,9* | *5+10* | *GliD1.1* | *NO* | *WT* | - | - | - | - | - |
| *Oakes* | *OVA10* | *Ax1* | *By8* | *2+12* | *GliD1.1* | *NO* | *WT* | *569* | *Sr36* | *Rht 2* | *D1a* | *NO* |
| *Oakes (Syngenta)* | *WQC10* | *Ax1/Ax2** | *By8* | *2+12* | *GliD1.1* | *NO* | *WT* | *569* | *Sr36 het* | *Rht 2* | *D1a* | *NO* |
| *OH 04 264-58* | *WQC08* | *Ax2** | *Bx7oe* | *5+10* | *GliD1.1/1.2* | *NO* | *WT* | *650-700* | - | - | - | - |

| Cultivar Name | Reference | HMW GluA1 | HMW GluB1 | HMW GluD1 | Gamma Gliadin | Rye Translocation | Waxy | Vp1 Pre Harvest Sprout | Sr 36 Rust Res | Dwarfing Rht1,2,8 | Photo-period Ppd D1a | FHB Resistance |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OH04-264-58 | WQC09 | Ax2* | Bx7oe | 5+10 | GliD1.2 | NO | WT | 650-700 | NO | Rht 2 | D1a | NO |
| OH101-1 | WQC09 | Ax1 | Not Bx7oe | 5+10 | GliD1.2 | NO | WT | 650-700 | NO | Rht 1 | D1a | NO |
| OH751 | WQC10 | Ax1 | By8 | 2+12 | GliD1.1 | NO | WT | 650-700 | Sr36 | NO | NO | NO |
| Patterson | WQC06 | Ax1 | By9 | 5+10 | GliD1.1 | NO | WT | - | - | - | - | - |
| Pioneer 25R39 | WQC08 | Ax2* | By9 | 2+12 | GliD1.1 | NO | WT | 569 | - | - | - | - |
| Pioneer 25R47 | WQC08 | Ax2* | By8 | 2+12 | GliD1.1 | NO | WT | 569 | - | - | - | - |
| Pioneer26R15 | WQC09 | Ax2* | Not Bx7oe | 5+10 | GliD1.1 | NO | WT | 569 | NO | Rht 1 | D1a | |
| Pur 011007A1-14 | WQC06 | Ax2* | Not By8,9 | 2+12 | GliD1.1 | NO | WT | - | - | - | - | - |
| Pur 02444A1-23-9 | WQC08 | Ax2* | Bx7oe | 2+12 | GliD1.1 | NO | WT | 650-700 | - | - | - | - |
| Pur 04287A1-10 | WQC08 | Ax1 | Bx7oe/By9 | 5+10 | GliD1.1 | 1BS/1BL | WT | 650-700 | - | - | - | - |
| Pur 981477A1 | WQC06 | Ax2* | By9 | 5+10 | GliD1.2 | 1BS/1BL (possible mix) | WT | - | - | - | - | - |
| Pur 99600A2-4-32 | WQC08 | Ax2* | By9 | 2+12 | GliD1.1 | NO | WT | 650-700 | - | - | - | - |
| Pur03112A1-7-3 | WQC08 | Ax1 | By9 | 2+12/5+10 | GliD1.1/1.2 | 1BS/1BL | WT | 650-700 | - | - | - | - |

| Cultivar Name | Reference | HMW GluA1 | HMW GluB1 | HMW GluD1 | Gamma Gliadin | Rye Translocation | Waxy | Vp1 Pre Harvest Sprout | Sr 36 Rust Res | Dwarfing Rht1,2,8 | Photo-period Ppd D1a | FHB Resistance |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Renegade* | *OVA10* | *Ax2** | *Bx7oe* | *2+12/5+10* | *GliD1.1* | *NO* | *WT* | *650-700* | *NO* | *Rht 1* | *D1a* | *NO* |
| *Saranac* | *WQC10* | *Ax2** | *By8* | *2+12* | *GliD1.1* | *NO* | *WT* | *650-700* | *NO* | *Rht 2* | *NO* | *FHB1* |
| *Shirley* | *OVA10* | *Ax1* | *By8* | *2+12* | *GliD1.1* | *1BS/1BL* | *WT* | *650-700* | *Sr36* | *Rht 1* | *D1a* | *NO* |
| *SSMPV 57* | *WQC07* | *Ax1* | *By16* | *2+12* | *GliD1.2* | *1BS/1BL* | *WT* | - | - | - | - | - |
| *SW049029104* | *WQC09* | *Ax2** | *Not Bx7oe* | *2+12* | *GliD1.1* | *NO* | *WT* | *569* | *NO* | *Rht 2* | *D1a* | *NO* |
| *SY9978* | *WQC10* | *Ax1* | *Bx7oe* | *2+12* | *GliD1.1* | *NO* | *WT* | *650-700* | *NO* | *Rht 1* | *D1a* | *NO* |
| *Tribute* | *WQC09* | *Ax2** | *Not Bx7oe* | *5+10* | *GliD1.1* | *1RS/1AL* | *GBSS _Aa null* | *569* | *NO* | *Rht 2* | *NO* | *NO* |
| *USG 3209* | *WQC07* | *Ax1/Ax2** | *By9* | *5+10* | *GliD1.1* | *1BS/1BL* | *WT* | - | - | - | - | - |
| *USG 3209.1* | *WQC08* | *Ax1* | *By9* | *5+10* | *GliD1.1* | *1BS/1BL* | *WT* | *Het* | - | - | - | - |
| *USG3120* | *WQC10* | *Ax2** | *By8* | *5+10* | *GliD1.1* | *1BS/1BL* | *WT* | *650-700* | *NO* | *Rht 2 / 8* | *NO* | *NO* |
| *USG3295* | *WQC10* | *Ax1* | *By8* | *2+12* | *GliD1.2* | *1BS/1BL* | *WT* | *650-700* | *Sr36* | *Rht 2* | *D1a* | *NO* |
| *USG3550* | *WQC09* | *Ax2** | *Not Bx7oe* | *5+10* | *GliD1.1* | *NO* | *WT* | *650-700* | *NO* | *Rht 1* | *NO* | *NO* |

| Cultivar Name | Reference | HMW GluA1 | HMW GluB1 | HMW GluD1 | Gamma Gliadin | Rye Translocation | Waxy | Vp1 Pre Harvest Sprout | Sr 36 Rust Res | Dwarfing Rht1,2,8 | Photo-period Ppd D1a | FHB Resistance |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| USG3555 | OVA10 | Ax2* | Not Bx7oe | 2+12 | GliD1.1 | 1BS/1BL | WT | 650-700 | Sr36 | Rht 2 | D1a | NO |
| USG3555.1 | WQC09 | Ax2* | Not Bx7oe | 2+12 | GliD1.1 | 1BS/1BL | WT | 650-700 | Sr36 | Rht 2 | D1a | FHB1-het |
| USG3565 | WQC09 | Ax1/Ax2* | Not Bx7oe | 2+12 | GliD1.1 | NO | WT | 569 | NO | Rht 2 | D1a | NO |
| VA01W-205 | WQC08 | Ax1 | By9 | 2+12 | GliD1.1 | NO | WT | 650-700 | - | - | - | - |
| VA03W-409 | WQC08 | Ax1 | By9 | 2+12 | GliD1.1 | 1BS/1BL | WT | 650-700 | - | - | - | - |
| VA03W-434 | WQC08 | Ax1 | Not By8,9 | 2+12 | GliD1.1 | 1BS/1BL | WT | 650-700 | - | - | - | - |
| W 1377 | WQC08 | Ax1 | Not By8,9 | 2+12 | GliD1.1 | NO | WT | 650-700 | - | - | - | - |
| W1062 | WQC09 | Ax2* | Not Bx7oe | 5+10 | GliD1.1 | NO | WT | 650-700 | NO | Rht 2 | NO | NO |
| W1104 | WQC09 | Ax2* | Bx7oe | 2+12 | GliD1.1 | 1BS/1BL | WT | 569 | NO | Rht 1 | D1a | 5AS-Ernie |
| W1566 | WQC09 | Ax1 | Not Bx7oe | 2+12 | GliD1.1 | 1BS/1BL | WT | 569 | NO | Rht 1 | D1a | NO |
| Yorkstar | WQC09 | Ax1 | Not Bx7oe | 5+10 | GliD1.1 | NO | WT | 650-700 | NO | Rht 2 | D1a | NO |

# Falling Number Research on Wheat

MARYLAND GRAIN PRODUCERS UTILIZATION BOARD RESEARCH

**Terminal Report Falling Number Research on Wheat (pre-harvest sprouting)**
**USDA Agricultural Research Service Agreement 58-3607-9-536**

Edward Souza, USDA-ARS, Soft Wheat Quality Laboratory, Wooster, OH.
Collaborators: José M. Costa and Robert Kratochvil, University of Maryland at College Park, Plant Science and Landscape Architecture.

**Summary**
The Maryland Grain Producers provided the USDA Soft Wheat Quality Laboratory with new laboratory mixers and water baths to increase our capacity to measure pre-harvest sprouting damage with the goal of reducing grower losses resulting from this recurring marketing problem. We evaluated trials in Maryland for three years in collaboration with the University of Maryland. The main conclusions were: 1) cultivars differ greatly in their sensitivity to moisture/rainfall after maturity, with Coker 9553, McCormick, SS 8302, and SS 8404 being the least prone to pre-harvest sprouting as measured by Hagburg Falling Number Test, and 2) α-amylase enzyme activity, which falling number measures indirectly, often does not increase immediately in all cultivars and often is not significant until falling number values are significantly less than 300 seconds. The cultivar information is directly useful for grower planting decisions. Also, the α-amylase results should assist with marketing moderate falling number grain lots (240 sec to 350 sec) at a greater price.

**Background**
Pre-harvest sprouting in wheat occurs when the crop is exposed to rain after a field reaches maturity. Sprouting of the grain produces α-amylase, an enzyme that rapidly breaks starch into simple sugars. The value of the grain declines rapidly as the level of α-amylase increases. Grain elevators pay lower prices to growers who deliver sprouted grain because they have very limited options for resale of the grain. In cases of severe sprouting, the only option is use for animal feed.

Cultivars of soft red wheat differ greatly in their tolerance to rain at maturity. The red pigmentation of the seed coat protects the grain from sprouting by delaying the onset of germination. Varieties also differ in their level of embryo dormancy. Some cultivars remain dormant and unable to germinate for many days and, in some cases, for weeks after the grain reaches maturity. Determining which cultivars minimize the risk of grower crop loss often requires multiple years of testing. Temperature differences during grain-filling can influence the level of dormancy, with warm temperatures inducing dormancy that can mask genetic effects.

Falling Number is the standard test used by the grain industry (AACC Method 56-81B) to measure pre-harvest sprouting. The degree of sprouting is measured by heating a sample of meal or flour in a water solution to gelatinize the starch, thickening the solution. A plunger is dropped through the thickened slurry. The more degraded the starch is by enzymes, the faster the plunger drops. The test units are expressed in seconds with 60 seconds a minimum number for the test, as that is the time for heating the solution before the plunger drops. In addition to pre-harvest sprouting, grain moisture, grain protein concentration, meal or flour particle size and native (un-sprouted) structure of the starch all affect the time for the plunger to drop. Numbers above 400 seconds reflect factors other than α-amylase activity (such as particle size). The correlation between α-amylase activity and falling number is best for samples with falling number values between 200 and 300 seconds. For cake flours and batters, 350 seconds is a common minimum value. For breakfast cereals or cookies and other high sugar products, values of 250 seconds are more common cut-offs.

**Results**

We evaluated trials in 2008 and 2009 from the 'Spike Protection Study' managed by Dr. Kratochvil and, in 2008 to 2010, from early and late harvest dates of the state cultivar trial managed by Dr. Costa. Individual year analyses and two-year summaries have been presented in Dr. Kratochvil and Dr. Costa's report to the Maryland Grain Producers. Across three years of falling number studies, Coker 9553, McCormick, SS 8302, and SS 8404 were the least affected by exposure to weather after maturity (Table 16). Because maturity dates vary between cultivars, the best method for interpreting the falling number information is to make comparisons between cultivars of similar maturity (early to early, late to late, etc.).

In 2008, we reorganized our laboratory with the equipment purchased through this grant and began testing high-throughput α-amylase assays. In 2009, we applied this testing to the state wheat trials, provided by Dr. Costa. A summary of that information and a comparison to Falling Number testing is presented in his interim report. We plan to prepare the results of this work for publication in research journals used by the grain trade. The most important conclusion of the work is a calibration curve that relates falling number directly to α-amylase. To our knowledge, this is not available elsewhere for soft wheat. Increasing grain hardness increases the falling number time. The amount of α-amylase present in a soft wheat at 300 seconds of falling number will be much less than that present in a hard wheat. Hence, we need to publish these levels of α-amylase and falling number specifically for soft wheat from the mid-Atlantic area (Figure 1).

We also observed an initial reduction in falling number that was independent of α-amylase activity (Figure 2). In comparing early harvested to late harvested grain, we observed as much as 100 to 150 seconds reduction in falling number before any measureable change in α-amylase activity occurred. The decline in falling number may be due to swelling of the starch granules through hydration or it may be due to other enzymatic activity, such as proteases or lipases that are reducing the resistance of other large molecules in the grain (proteins and fats) to the falling of the test plunger. Commercial mills and bakeries often do see changes in product quality during that first 100 second decline in the Falling Number test. Yet, we are questioning if it is related to α-amylase or some other component of the seed that might be more readily controlled in the bakery. We plan to continue this work in collaboration with the University of Maryland researchers.

**Table 16. Falling number analysis of pre-harvest sprouting damage of soft red winter wheat cultivars exposed to weathering, contrast of early and late harvest averaged across 2008 and 2010**

| | Early harvest | Late harvest | Difference |
|---|---|---|---|
| | sec. | sec. | sec. |
| Coker 9553 | 409 | 303 | -105 |
| McCormick | 431 | 313 | -118 |
| SS 8302 | 368 | 243 | -125 |
| SS 8404 | 398 | 249 | -149 |
| FS 627 | 432 | 277 | -155 |
| Branson | 421 | 254 | -167 |
| SS 8309 | 409 | 235 | -174 |
| SS MPV57 | 397 | 218 | -179 |
| USG 3665 | 410 | 227 | -183 |
| Chesapeake | 353 | 145 | -208 |
| SS 560 | 411 | 177 | -235 |
| Jamestown | 411 | 172 | -239 |
| SS 520 | 392 | 152 | -240 |
| USG 3592 | 367 | 125 | -242 |
| SS 5205 | 403 | 160 | -243 |
| FS 621 | 398 | 143 | -255 |
| USG 3342 | 424 | 168 | -256 |
| USG 3209 | 426 | 167 | -258 |
| USG 3555 | 437 | 178 | -259 |
| 25R62 | 389 | 128 | -261 |
| Standard error | 10 | 10 | |

**Figure 1. α-amylase increases as falling number values decrease, with minor accumulation below 350 seconds and substantial accumulation below 200 seconds.**

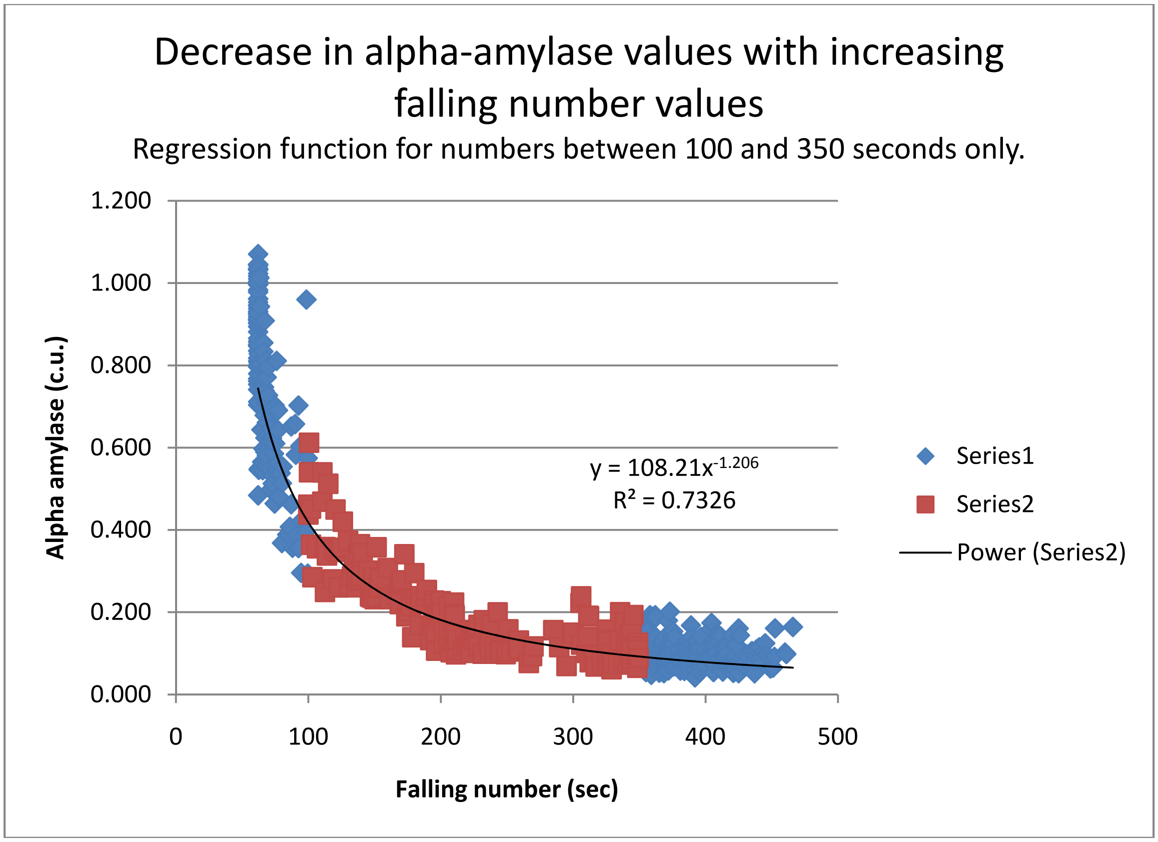
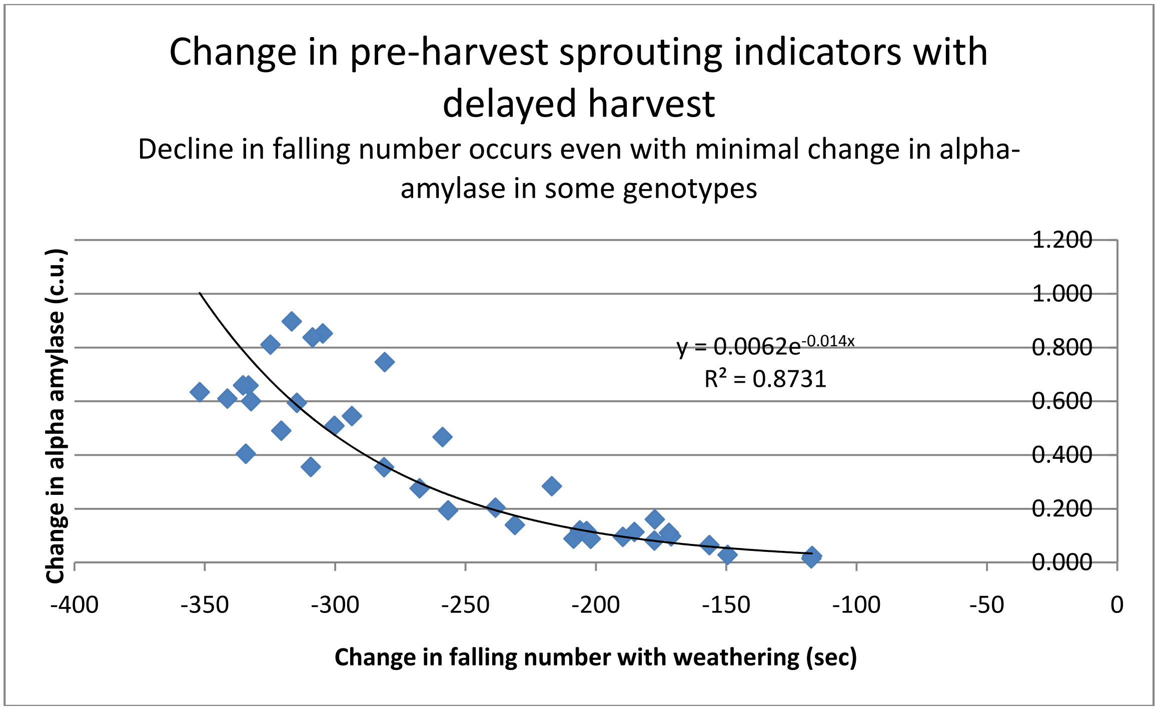


**Figure 2. Comparison of paired tests for cultivars averaged across 2009 and 2010; late harvest values were subtracted from early harvest values for falling number and α-amylase activity. Significant reductions in Falling Number tests can occur without increase in α-amylase.**



**Materials and Methods for Falling Number Study**
Wheat cultivars were planted at all locations in seven-row plots, 5 m in length and later trimmed to 4 m in randomized blocks with three replications per entry. Plots were planted in rows separated by 0.15 m. Wheat was seeded at a rate of 18 seeds per 0.30m of row. Plots were mechanically harvested using a small plot combine (Wintersteiger Seedmech Nurserymaster Elite).

Crops for the first year (2007-2008) were planted on October 8, 2007, in Clarksville, MD in a Chester gravely soil with a pH of 6.6. The previous crop at this site was corn with conventional tillage. In the fall of 2007, application of 7-18-36 UAN fertilizer was made at 150 lbs/acre. In the spring of 2008, application of N as 30-0-0 UAN was made at 65 lbs/acre. Harmony Xtra herbicide was applied at 0.5 oz/acre. Early harvest of crops occurred on June 26, 2008; late harvest occurred on July 17, 2008.

Crops for the second year (2008-2009) were planted on October 24, 2008, at Poplar Hill in Quantico, MD in a Mattapex silt loam with a pH of 6.2. The previous crop at this site was corn. In the fall of 2008, fertilizer was applied in the following concentrations: N at 30 lbs/acre, P at 20 lbs/acre, K at 80 lbs/acre and S at 24 lbs/acre. At greenup in the spring of 2009, 40 lbs/acre N was applied as 30% UAN. At GS 6 in the spring of 2009, 60 lbs/acre was applied as 30% UAN. Harmony Xtra herbicide was applied on March 6, 2009, at 0.75 oz/acre. At heading, Warrior insecticide was applied at 3.5 oz/acre. Early harvest of crops occurred on June 22, 2009; late harvest occurred on August 3, 2009.

Crops for the third year (2009-2010) were planted on October 12, 2009, in Queenstown, MD (Wye) in a Mattapeake/Mattapex silt loam. The previous crop at this site was corn with conventional tillage. On October 9, 2009, application of 10-10-10 UAN fertilizer was made at 300 lbs/acre. On March 10, 2010, 60 lbs/acre N was applied as 30% UAN. On April 7, 2010, 40 lbs/acre N was applied as 50/50 water/30% UAN. Harmony herbicide was applied on April 6, 2010, at 0.8 oz/acre. Weather data for the third year (2009-2010 at Queenstown) can be found online at: http://agresearch.umd.edu/recs/WREC/WeatherData.cfm.

# Stem Rust Resistance

Resistance to stem rust Ug99 (race TTKS of *P. graminis*) is a priority for breeding wheat. The stem rust gene *Sr36 gene*, originally derived through a translocation in crosses with *Triticum timopheevi*, was reportedly effective against Ug99 stem rust (Jin, et al, 2007)[1]. The gene was localized to chromosome 2B, and is identified by a codominant SSR marker, *wmc477* (Tsilo, Toi J et al. 2008)[2]. Approximately 20% of the 187 members of the association mapping population carried the *Sr36* gene via the 2B translocation, so it is relatively common in commercial cultivars. No associated detrimental effects on quality measurements were associated with these cultivars in studies of the association mapping population at the Soft Wheat Quality Lab in Wooster. Cultivars known to carry the *Sr36* 2B translocation are listed below.

**Table 17. Cultivars carrying the *Sr36* Stem Rust resistance gene**

| | | |
|---|---|---|
| Abe | Adder | Adena |
| AGI 401 | AGRA Rubin* | AGRA Silas |
| AGRA Trevor* | Arcadia | Arthur |
| Beck 122* | Beck 137 | Buckeye |
| Coker 47-27 | Coker 747 | Coker 762 |
| Coker 797 | Coker 833 | Coker 916 |
| Coker 9663 | Coker 9766 | Coker 9803 |
| Coker 9835 | Compton | Dominion |
| Doublecrop | Dyna-Gro 9911 | Ebberts 501 |
| Ebberts 590 | FFR 555 | Foster |
| Freedom | Gries Beuerlein* | INW 0411 |
| INW0316 | Jaypee | Jordan |
| Kenosha | Madison | Magnum |
| Massey | McNair 1003 | McNair 1813 |
| MO 11126* | Neuse NC | Oakes |
| OH751 | Pioneer 2643 | Pioneer 2684 |
| Pioneer 26R31 | Progold | Rupp 9xp34 |
| Scotty | Seed Consultants SC 1325 | Seed Consultants SC 1358 |
| Severn | Shirley | Shur Grow SG-1567 |
| Sisson | Steyer | Sullivan |
| Tecumseh | USG3209 | USG3295 |
| USG3555 | VA 96W-247 | VA03W-412* |
| Wheeler | | |

[1] Jin et al., 2007, Characterization of Seedling Infection Types and Adult Plant Infection Responses of Monogenic *Sr* Gene Lines to Race TTKS of Puccinia graminis f. sp. *Tritici*, Plant Disease, Vol 91, No. 9, 1096-1099.

[2] Tsilo, Toi J., et al, 2008, Diagnostic Microsatellit Markers for the Detection of Stem Rust Resistance Gene Sr36 in Diverse Genetic Backgrounds of Wheat, Crop Science, Vol 48, 253-261.

# 2011 Soft Wheat Quality Lab Focus on Research

*Basis for Selecting Soft Wheat for End-Use Quality* [3] was submitted for publication in 2011. The manuscript describes phenotypic evaluation over two years and five locations of 187 soft winter wheat cultivars, released from 1801 to 2005, from the eastern United States germplasm pool as an association mapping population. A second publication is in preparation on genotyping in this same population.

The phenotyped association mapping population is a valuable resource and we will continue to add genetic information in 2011. Kansas State University's Eduard Akhunov is analyzing the population for Single Nucleotide Polymorphism (SNP) analysis using OPA technology (Illumina, Custom GoldenGate Oligonucleotide Pool Assays). Also in collaboration with KSU, we have extracted a list of 100+ genes with published sequence and related to physiological pathways such as seed formation, endosperm development, starch and non-starch polysaccharide synthesis, cell wall structure, disease, drought and stress responses. This set of genes will be sequenced using 454 (Roche) next generation sequencing technology across the AM population. Taking advantage of the population's variable milling and baking qualities, we hope to link novel SNPs to flour quality.

We have been working with a bi-parental mapping population for milling quality, Foster x Kanqueen, developed at Cornell University through Mark Sorrells. Foster and Kanqueen respectively represent excellent and poor milling qualities. This year we will evaluate $BC_1F_5$ generation seed from recombinant inbred lines grown in the field, selected over three generations for markers associated with a milling quantitative trait locus (QTL) on chromosome 2B.

Softness in soft wheat is controlled by the dominant allele at the Hardness locus (*Ha*) on Chromosome 5D. Wild type hexaploid wheat lacks the *Ha* locus from the A genome. We produced experimental lines containing both the wild-type soft allele at the *Ha* locus from Chromosome 5D and an additional soft allele from chromosome 5A through an alien introgression line derived from *Triticum monococcum.* Tranquilli [4] and See[5] each showed that the presence of the double allele for softness (on both A and D genomes) produced softer grains. This year we will harvest our experimental lines and plant an increase in the field for 2012 milling evaluations.

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[3] Edward J. Souza, Clay Sneller, Mary J. Guttieri, Anne Sturbaum, Carl Griffey, Mark Sorrells, Herbert Ohm, and David Van Sanford, 2011 (submitted)

[4]Tranquilli, G., J. Heaton, O. Chicaiza, and J. Dubcovsky. 2002. Substitutions and deletions of genes related to grain hardness in wheat and their eff ect on grain texture. Crop Sci. 42:1812–1817

[5] See, D.R., M. Giroux, and B.S. Gill. 2004. Effect of multiple copies of puroindoline genes on grain softness. Crop Sci. 44:1248–1253.

# New Wheat Cultivars

Information on new releases is important to breeders in the wheat community. We include a compilation of new releases for the past two years. Descriptions of new wheat cultivars are listed by contributing collaborator. The SWQL thanks each of the breeders, growers and researchers for his/her contributions providing cultivar descriptions for this report.

## Agricultural Alumni Seed Improvement Association, Inc.

**INW1021 (P02444A1-23-9)**
Soft red winter wheat

INW1021 has consistently been in the top group of entries in yield. INW1021 has Fhb1 (moderate FHB resistance), the Lr37Yr17Sr38 rust resistance linkage block, good soft wheat milling and baking qualities and the Bx70e strong gluten allele; the Rht1 dwarfing allele and the Ppd daylength insensitive allele (one reason for its wide adaptability). Plant height of INW1021 is similar to that of Patterson and Bess, it is awnless, has large spikes, tillers well and has moderately strong straw. It has moderate resistance to Fusarium head blight, Yellow Dwarf Virus, Wheat Spindle Streak Mosaic Virus, Soilborne Mosaic Virus, leaf, stem and stripe rusts, powdery mildew, *Stagonospora Nodorum* blotch, Septoria leaf blotch, and is susceptible to Hession fly biotype L. INW1021 typically heads one day earlier than Patterson (one day later than Clark) in southern IN and one day later than Patterson (three days later than Clark) in northern IN (a bit unusual… but probably because INW1021 has the Ppd daylength insensitive allele).

**AG 2581**
Soft red winter wheat

AG 2581 is a medium height variety normally averaging less than 36 inches in height under good fertility with excellent straw strength. The disease package is quite exceptional which allows it to perform well in all environments found throughout the Soft Red Winter Wheat growing area. It has shown a unique ability to remain one of the top performers under disease attacks of
Fusarium, stripe rust and Barley Yellow Virus. Where conditions are favorable and under high fertility levels it has a proven record of performing with, and in many cases, well above the industry leaders. In a word "it works."

## AgriPro COKER Syngenta Seeds, Inc.

Barton Fogleman

**W1062**
Soft white winter wheat

W1062 is a soft white winter wheat exclusively marketed by Syngenta Cereals (AgriPro business unit) for grain production. W1062 is a medium to medium-tall height wheat with medium to medium-full season heading. W1062 is moderately resistant to the powdery mildew races prevalent in Michigan in 2007 and 2008 and is moderately resistant to the leaf rust races prevalent in Michigan, NW Ohio, and W. Kentucky in 2007 and 2008.

W1062 has shown better tolerance to in-head sprouting and better falling number data in weathered samples than most soft white winter wheats currently grown in Michigan. W1062 has shown very good milling flour yields and very good cookie baking properties. Its Lactic Acid scores indicate some level of gluten strength.

W1062 is best adapted for grain production in Michigan and NW Ohio.

**W1566**
Soft red winter wheat

W1566 is a soft red winter wheat bred by Syngenta Cereals (AgriPro business unit) for grain and wheat straw production. W1566 is a relatively tall semidwarf wheat and is of medium maturity with heading date similar to Cooper. W1566 has shown very good winter hardiness and vigorous spring growth.

W1566 has shown resistance to current field races of powdery mildew (Mich. ’05, ’07). It is moderately susceptible to current field races of leaf rust. It has shown moderately susceptibility to the soil virus complex (WSBMV/WSSMV in Urbana, IL, ’08, ’09). From data gathered from southern Illinois and Indiana fields in 2009, it is likely that W1566 is resistant/mod. resistant to Wheat Spindle Streak Mosaic Virus (WSSMV), but susceptible to WSBMV. W1566’s winter hardiness is reduced somewhat where WSBMV is active. W1566 has shown good milling flour yields and acceptable cookie baking properties.

W1566 appears to be best adapted for grain and wheat straw production in the states of Illinois, Indiana, Kentucky, Michigan, Ohio, Wisconsin, Delaware, Maryland, North Carolina, Pennsylvania, and Virginia.

**W1104**
Soft red winter wheat

W1104 is a soft red winter wheat bred by Syngenta Cereals (AgriPro business unit) for grain production. W1104 is a relatively short height wheat and is medium maturity with height and heading date similar to Cooper. W1104 has shown resistance to moderate resistance to the soil virus complex (WSBMV/WSSMV in Urbana, IL, ‘08 and ’09). W1104 has shown moderate resistance to the races of leaf rust present in OH, KY and TN in 2007 and 2008. W1104 showed moderate susceptibility to field races of powdery mildew (Mich. ’07). W1104 has shown acceptable milling and cookie baking properties in three years of testing.

W1104 has shown its best yield response to standard levels of nitrogen fertilizer and does not appear to benefit from very high fertility levels.

W1104 appears to be best adapted for grain production in the states of Illinois, Indiana, Kentucky, Michigan, and Ohio.

**W1377**
Soft red winter wheat

W1377 is a soft red winter wheat bred by Syngenta Seeds, Inc., for grain and wheat straw production. W1377 has consistently produced very high test weight grain. It is a medium-tall height wheat with medium heading (about two days later than Branson). W1377 has shown very good resistance to stripe rust. It has shown moderate resistance to leaf rust in the Midwest and upper Midsouth. W1377 has shown susceptibility to powdery mildew in Michigan and the Northeast. It has demonstrated very good forage and straw production in the Kentucky trials. At maturity its straw has an attractive “snowy” bright color.

## Beck's Superior Hybrids

Kris Johnson, Brent Minett

**BECK 134**
BECK 134 is a new high yielding product for the Southern and Central portion of Beck's marketing area. This awned product is medium early, stands well, and responds to higher management scenarios. BECK 134 is built for soils with high yield potential and will please you with its yield results.

**BECK 135**
BECK 135 is the new yield leader in wheat. This awned product is widely adapted and delivers top end performance. BECK 135 stands well and responds to higher management. BECK 135 had a performance advantage over all other varieties tested.

**BECK 87**
BECK 87 is the earliest product in the marketplace. This product heads incredibly early and dries down fast with excellent resistance to Fusarium head scab and excellent test weight. BECK 87 will move double crop potential far to the north and help farmers in the south gain additional soybean yields.

**BECK 137**
BECK 137 is an improved version of BECK 117. This variety has a similar genetic background and offers a more uniform look and is higher yielding. Place BECK 137 just like BECK 117 and enjoy similar characteristics such as high test weight and tremendous winter hardiness with additional yield.

**BECK 164**
BECK 164 is a very high yielding stable performer that has excellent resistance to head scab and great winter hardiness. BECK 164 dominated the Central and Northern portions of Beck's Marketing Area in 2007 and is an excellent all-around wheat variety.

**BECK 113**
BECK 113 is a tremendous new double crop option for the southern part of Beck's marketing area. It heads very early and offers fast dry down for early harvest. It responds to higher seeding populations and offers tremendous standability for great double cropping.

## Cornell University

Mark E. Sorrells

**NY03180FHB-10**
Soft white winter wheat

Pedigree: NY7387/Caledonia//Caledonia-2///Caledonia 9-10 (BC2F4 selection). This is the first molecular marker assisted variety developed and released by Cornell.

Grain Yield: In three years of testing, this line averaged 4 b/a higher grain yield than Jensen, 2 b/a higher than Richland, and 2 b/a below Caledonia.
Test Weight: Average test weight is similar to Caledonia.
Winter Hardiness: Winter survival is similar to current varieties.

Lodging Resistance: NY03180FHB-10 is similar to Jensen but more susceptible than Caledonia or Richland for lodging resistance.

Disease Resistance: NY03180FHB-10 is much more resistant to Fusarium head blight (scab) than Caledonia and is similar to Jensen. It is highly resistant to Wheat Spindle Streak Mosaic Virus and Wheat Soil Borne Mosaic Virus. This variety is moderately resistant to powdery mildew. Reaction to other diseases is unknown.

Quality Characteristics: NY03180FHB-10 was evaluated for milling and baking quality in 2006 and 2007 and appears to have excellent milling and baking properties comparable to Caledonia. It is resistant to pre-harvest sprouting with a score similar to Jensen.

Morphology: Plant height is about 83 cm compared to 77 cm for Caledonia and 88 for Richland. This line is awnless and has white chaff color. Heading date is similar to Caledonia or Richland.

Status of Breeder Seed: Approximately 20 pounds of Breeder seed were harvested in the fall of 2006 and planted in Michigan for seed increase in fall 2007. In the fall of 2008, 40 acres were planted in Michigan by Platinum Genetics. This line will be offered to the New York seed industry as an exclusive release with Breeder, Foundation, and Certified classes. PVP is pending.

Name: Some variant of the name Caledonia-FHB will be explored to take advantage of the success of the previous variety.

**Saranac (NY03179FHB-12)**
Soft white winter wheat

Morphology: This variety is very similar to Caledonia in appearance, and plant height is the primary distinguishing feature. Plant height is about 85 cm compared to 77 cm for Caledonia and 88 cm for Richland. This line is awnless and has white chaff color. Heading date similar to Caledonia or Richland.

Pedigree: NY7387/Caledonia//Caledonia-2///Caledonia 7-12 (BC2F4 selection). This is the second molecular marker assisted variety developed by Cornell.

Grain Yield: In three years of testing, this line averaged 3 b/a higher grain yield than Jensen, 1 b/a higher than Richland, and 3 b/a below Caledonia.

Test Weight: Averaging 1 lb/bu below Caledonia.

Winter Hardiness: Winter survival is similar to current varieties.

Lodging Resistance: NY03179FHB-12 is similar to Caledonia and Richland and better than Jensen for lodging resistance.

Disease Resistance: NY03179FHB-12 is much more resistant to Fusarium head blight (scab) than Caledonia with half the incidence and very low severity scores. It is rated as resistant to Wheat Spindle Streak Mosaic Virus and Wheat Soil Borne Mosaic Virus. This variety is moderately resistant to powdery mildew. Reaction to other diseases is unknown.

Quality Characteristics: NY03179FHB-12 was evaluated for milling and baking quality in 2006 and 2007 and appears to have satisfactory milling and baking properties comparable to Caledonia. It is moderately susceptible to pre-harvest sprouting, slightly better than Caledonia.

Status of Breeder Seed: Approximately five acres of Breeder seed were planted in the fall of 2008 in New York and 100 acres were planted in Michigan. This line will be offered to the New York seed industry as a non-exclusive release variety with Breeder, Foundation, and Certified classes. PVP is pending.

Name: We have approval for the name “Saranac”. The PVP application will be submitted fall 2011.

**NYCal4PHS-10**
Soft white winter wheat

Pedigree: Caledonia/Cayuga//Caledonia 4-10 (BC1F4 selection). This is the third molecular marker assisted variety developed and released by Cornell.

Grain Yield: In three years of testing, this line averaged 5 b/a higher grain yield than Jensen, 3 b/a higher than Richland, and 1 b/a below Caledonia.

Test Weight: Average test weight is similar to Caledonia.

Winter Hardiness: Winter survival is similar to current varieties.

Lodging Resistance: NYCal4PHS-10 is similar to Jensen but more susceptible than Caledonia for lodging resistance.

Disease Resistance: NYCal4PHS-10 is susceptible to Fusarium head blight (scab) but appears to be more resistant than Caledonia. It is resistant to Wheat Spindle Streak Mosaic Virus and Wheat Soil Borne Mosaic Virus. This variety is moderately susceptible to powdery mildew. Reaction to other diseases is unknown.

Quality Characteristics: NYCal4PHS-10 was evaluated for milling and baking quality in 2006 and 2007 and appears to have excellent milling and baking properties comparable to Caledonia. It is moderately susceptible to pre-harvest sprouting.

Morphology: Plant height is about 80 cm compared to 77 cm for Caledonia and 88 cm for Richland. This line is awnless and has white chaff color. Heading date similar to Caledonia or Richland.

Status of Breeder Seed: Ten acres of Breeder seed were planted in the fall of 2008 in Michigan. This line will be offered to the seed industry as an exclusive release variety with Breeder, Foundation, and Certified classes. PVP is pending.

Name: The name will be determined by selecting among four suggestions from the licensing company.

**JENSEN** (NY88046-8138)
Soft white winter wheat

Pedigree: Susquehanna/Harus

Morphology: Plant height is 2-4 inches taller than Caledonia and nearly the same height as Richland. This line is awnless and has white chaff color. Heading date about two days later than Caledonia or Richland.

Grain Yield: Over four years, this line is similar in grain yield to Caledonia and Richland at 76 b/a.

Test Weight: NY88046-8138 has excellent test weight and is averaging 57.4 lbs/bu over four years versus 55.7 lbs/bu for Caledonia and 56.3 lbs/bu for Richland.

Winter Hardiness: Winter survival is similar to current varieties.

Resistance: Lodging resistance of NY88046-8138 appears to be comparable to Richland. Caledonia may be slightly more lodging resistant.

Disease Resistance: NY88046-8138 is more resistant than current soft white wheat varieties to Fusarium head blight (scab). It is rated as moderately resistant to Wheat Spindle Streak Mosaic Virus and susceptible to Wheat Soil Borne Mosaic Virus. The powdery mildew rating is better than all other current varieties except Richland. Seedling tests at Virginia Tech show that NY88046-8138 is resistant to a powdery mildew composite with virulence for resistance genes Pm1,2,3,3a,3c,3f,4a,4b,5,6,7. NY88046-8138 is moderately susceptible to leaf rust race TNRJ. Reaction to other diseases is unknown.

Quality Characteristics: From four different evaluations over three years, NY88046-8138 appears to have satisfactory milling and baking properties and is comparable to Caledonia and Richland. It is moderately resistant to pre-harvest sprouting with a sprouting score higher than Cayuga but much lower than all other current varieties.

Status of Breeder Seed: Approximately two acres of Breeder seed were planted in the fall of 2005. This line is a public release with Breeder, Foundation, and Certified classes. PVP was submitted in fall 2007.

**OH751**
Soft red winter wheat

Pedigree: 10584-08-01 (IN71761a4-31-5-33 / MO55-286-21) / Coker9663 (IN71761A4-31-5-48 / FL 302)

Grain Yield: Over four years of testing, this line averaged 4 b/a higher grain yield than SW50 and 8 b/a above Truman. The three year summary shows a 1 b/a edge over Pioneer 25R47.

Test Weight: Oh751 averages 0.7 lbs/bu below Truman but 0.6 lbs/b above Pioneer 25R47.

Winter Hardiness: Winter survival is similar to current varieties.

Lodging Resistance: OH751 is similar to Pioneer 25R47 and Richland and much better than Truman for lodging resistance.

Disease Resistance: OH751 has excellent resistance to powdery mildew, leaf spot, glume blotch, leaf rust and moderate resistance to Fusarium head blight (scab). It is also resistant to Wheat Spindle Streak Mosaic Virus and Wheat Soil Borne Mosaic Virus. Reaction to other diseases is unknown.

Quality Characteristics: OH751 was evaluated for milling and baking quality over four years and it appears to have satisfactory milling and baking properties comparable to current varieties. It is resistant to pre-harvest sprouting.

Morphology: Plant height is about 90 cm compared to 92 cm for Truman and 84 cm for Pioneer 25R47. This line is awnless and has white chaff color. Heading date is one or two days later than Pioneer 25R47 or Truman.

Status of Breeder Seed: Approximately five acres of Breeder seed were planted in the fall of 2009 for Foundation seed production. This line will be offered to the New York seed industry as a non-exclusive release variety with Breeder, Foundation, and Certified classes. Ohio State University will apply for PVP.

Name: To be determined.

## Limagrain Cereal Seeds

Jim Peterson and Don Obert

**Excel 437**
Soft red winter wheat

Excel 437 is a SRWW owned by Limagrain Cereal Seeds and distributed by Bio-Plant Research, Ltd. of Camp Point, IL. The line will be released in 2011. It has very good winter-hardiness. The line is moderately resistant to Fusarium head scab, powdery mildew, stripe rust, and *Septoria tritici*. The line heads one day later than BW402 or Branson. The line has excellent yield. It is nearly the same height as Branson or Shirley. This line is moderately susceptible to leaf rust. It has good shattering resistance and has very good lodging resistance.

**Excel 339**
Soft red winter wheat

Excel 339 is a SRWW owned by Limagrain Cereal Seeds and distributed by Bio Plant Research, Ltd. of Camp Point, IL. The line will be released in 2011. The line has the same heading date as BW402 or Branson. It has very good yield potential. This line has good resistance to leaf rust, stripe rust and head scab, and is moderately susceptible to *Septoria tritici*. It has good winter hardiness, shattering resistance and standability.

**Excel Exp 350**
Soft red winter wheat

Excel Exp 350 is a SRWW owned by Limagrain Cereal Seeds and is scheduled to be released in 2012 by Bio Plant Research, Ltd. of Camp Point, IL. It has good resistance to powdery mildew, stripe rust and head scab and has good winter survival. It is similar in maturity to BW402 or Branson. This line is moderately susceptible to *Septoria tritici*. It is similar in height to Branson and Shirley.

**Excel Exp 321**
Soft red winter wheat

Excel Exp 321 is a SRWW owned by Limagrain Cereal Seeds and is scheduled to be released in 2012 by Bio Plant Research, Ltd. of Camp Point, IL. It has good resistance to powdery mildew, leaf rust, stripe rust and head scab and has good winter survival. It is similar in maturity to BW402 or Branson. This line is moderately susceptible to *Septoria tritici*. It is similar in height to Branson and Shirley. It is moderately susceptible to WSSMV.

**Excel Exp 525**
Soft red winter wheat

Excel Exp 525 is a SRWW owned by Limagrain Cereal Seeds. It is distributed by Bio Plant Research, Ltd. of Camp Point, IL, and is scheduled to be released in 2012. This line has excellent winter hardiness and is moderately resistant to leaf rust and *Septoria tritici*. It heads three days later than SR30-530J, Branson or BW402. This line has long tip awns, and is three inches taller than Branson or Shirley. This line is moderately susceptible to Fusarium head scab.

**Excel Exp 500**
Soft red winter wheat

Excel Exp 500 is a SRWW owned by Limagrain Cereal Seeds and distributed by Bio Plant Research, Ltd. of Camp Point, IL. The line is schedule to be released in 2012. It has very good resistance to *Septoria tritici*, leaf rust, and powdery mildew. This line is three days later in maturity than SR30-530J, Branson and BW402. It is three inches taller than Branson or Shirley, and is moderately susceptible to Fusarium head scab.

**Excel Exp 515**
Soft red winter wheat

Excel Exp 515 is a SRWW owned by Limagrain Cereal Seeds and is scheduled to be released in 2012 by Bio Plant Research, Ltd. of Camp Point, IL. It has very good resistance to BYDV and powdery mildew. This line has moderate resistance to black chaff and possesses very bright straw. It is tip awned and ripens early. This line has moderate resistance to *Septoria tritici*, leaf rust, WSSMV and powdery mildew. It heads four days later than SR30-530J, Branson or BW402. This line is two inches taller than Branson or Shirley.

**Excel Exp 333**
Soft red winter wheat

Excel Exp 333 is a SRWW owned by Limagrain Cereal Seeds and is scheduled to be released in 2012 by Bio Plant Research, Ltd. of Camp Point, IL. It has moderate resistance to powdery mildew, *Septoria nodurum* and leaf rust. It is moderately susceptible to *tritici*, scab, stripe rust and WSSMV. The line heads three days later and is two inches shorter than C9553.

**Excel Exp 188**
Soft red winter wheat

Excel Exp 188 is a SRWW owned by Limagrain Cereal Seeds and is scheduled to be released in 2012 by Bio Plant Research, Ltd. of Camp Point, IL. This line heads one day earlier than Branson or BW402. It yields very well for an early line, and has good test weight and winter hardiness. It has moderate resistance to powdery mildew and black chaff. The line is moderately susceptible to leaf rust. The line has bright golden straw and is the same height as Branson.

**Excel Exp 463**
Soft red winter wheat

Excel Exp 463 is a SRWW owned by Limagrain Cereal Seeds and is scheduled to be released in 2012 by Bio Plant Research, Ltd. of Camp Point, IL. This line has good straw characteristics, as well as a good level of resistance to stripe rust and head scab. It is moderately susceptible to leaf rust and to powdery mildew. This line heads two days later than SR30-530J, Branson and BW402. It is three inches taller than SR30-530J and Branson.

**Excel Exp 427**
Soft red winter wheat

Excel Exp 427 is a SRWW owned by Limagrain Cereal Seeds and is scheduled to be released in 2012 by Bio Plant Research, Ltd. of Camp Point, IL. This line appears to do best in KY, TN, and MO. It is moderately resistant to WSSMV, leaf rust, *Septoria tritici*, and black chaff. This line heads one day later than SR30-530J, Branson and BW402. It is four inches taller than SR30-530J and Branson.

**Excel Exp 329**
Soft red winter wheat

Excel Exp 329 is a SRWW owned by Limagrain Cereal Seeds and is scheduled to be released in 2012 by Bio Plant Research, Ltd. of Camp Point, IL. Excel Exp 329 is moderately resistant to powdery mildew and black chaff. The line is moderately susceptible to leaf rust. It has a larger seed size at 39.2g per TKW. This line heads on the same day as SR30-530J, Branson and BW402. It is the same height as SR30-530J and Branson.

**Excel Exp 394**
Soft red winter wheat

Excel Exp 394 is a SRWW owned by Limagrain Cereal Seeds and is scheduled to be released in 2012 by Bio Plant Research, Ltd. of Camp Point, IL. This line is moderately resistant to powdery mildew, and *Septoria tritici*. It is moderately susceptible to leaf rust and black chaff. This line has stiff straw, and heads one day later than SR30-530J, Branson and BW402. It is three inches taller in height than SR30-530J and Branson.

**Excel 341**
Soft red winter wheat

Excel 341 is a SRWW distributed by Bio-Plant Research, Ltd. of Camp Point, IL. The line was first released in 2007. It has very good winter hardiness and is moderately resistant to leaf rust, stripe rust, and *Septoria tritici*. The line heads two days later than SR30-530J or Branson. This line is moderately susceptible to powdery mildew.

**Excel 286**
Soft red winter wheat

Excel 286 is a SRWW distributed by Bio Plant Research, Ltd. of Camp Point, IL. The line was released in 2008. It is a medium-tall wheat. The line is medium early in maturity and heading date is the same as SR30-530J and Branson. It has very good yield potential. This line has good resistance to leaf rust, stripe rust and head scab, and is moderately susceptible to powdery mildew and *Septoria tritici*.

**Excel 314**
Soft red winter wheat

Excel 314 is a SRWW that was released in 2009 by Bio Plant Research, Ltd. of Camp Point, IL. It has good resistance to leaf rust, stripe rust and head scab and it is winter hardy. It is similar in maturity to SR30-530J and Branson. This line has moderate resistance to powdery mildew, *Septoria tritici* and head scab.

**Excel 271**
Soft red winter wheat

Excel 271 is a SRWW that was released in 2009 by Bio Plant Research, Ltd. of Camp Point, IL. It is a large seeded line with its 1000-kernal weight in 2008, an excellent growing conditions year, measuring 42.3 grams and it has exceptional test weight. This line has good resistance to leaf rust, *Septoria tritici*, stripe rust, and powdery mildew. This line heads two days later than SR30-530J and Branson.

**Excel 343**
Soft red winter wheat

Excel 343 is a SRWW distributed by Bio Plant Research, Ltd. of Camp Point, IL. The line was first released in 2008. This line has good winter hardiness and is moderately resistant to leaf rust, powdery mildew and *Septoria tritici*. It is moderately susceptible to stripe rust. It heads three days later than SR30-530J and Branson.

**Excel 302**
Soft red winter wheat

Excel 302 is a SRWW distributed by Bio Plant Research, Ltd. of Camp Point, IL. The line was first released in 2008. It has very good resistance to *Septoria tritici,* leaf rust, and powdery mildew. This line is three days later in maturity than SR30-530J and Branson.

**Excel 328**
Soft red winter wheat

Excel 328 is a SRWW that was released in 2009 by Bio Plant Research, Ltd. of Camp Point, IL. It has very good resistance to BYDV and powdery mildew. This line has moderate resistance to *Septoria tritici* and leaf rust. The line is moderately susceptible to stripe rust. The line heads four days later than SR30-530J and Branson.

**Excel 446**
Soft red winter wheat

Excel 446 is a larger seed SRWW that was released in 2010 by Bio Plant Research, Ltd. of Camp Point, IL. This line does particularly well in Ohio and the eastern U.S. It has very good resistance to powdery mildew, *Septoria tritici* and BYDV. The line is moderately susceptible to stripe rust. It is later maturing wheat, heading five days later than SR30-530J and Branson.

**Excel 336**
Soft red winter wheat

Excel 336 is a larger seed SRWW that was released in 2010 by Bio Plant Research, Ltd. of Camp Point, IL. This line has good test weight and winter hardiness. It has moderate resistance to powdery mildew, *Septoria tritici* and leaf rust. The line is moderately susceptible to stripe rust. The line heads the same as SR30-530J and Branson.

**Excel 410TW**
Soft red winter wheat

Excel 410TW is a SRWW distributed by Bio-Plant Research, Ltd. of Camp Point, IL. The line was released in 2007. This line has good winter hardiness and straw characteristics, as well as a good level of resistance to leaf rust, stripe rust and head scab. It is moderately resistant to powdery mildew and *Septoria tritici*. This line heads two days later than SR30-530J and Branson.

## Michigan State University

Janet Lewis

**Ambassador**
Soft white winter wheat

'Ambassador' (Reg. No. CV-1048, PI 656845, experimental name E0028) is a soft white winter wheat that was released by the Michigan Agricultural Experiment Station in 2007. Ambassador was selected from the cross of Pioneer '2737W' /D1148 made in 1994 at MSU. Ambassador was released because of its excellent grain yield, flour yield, and good winter hardiness. Its primary weaknesses include low test weight and high susceptibility to Fusarium head blight (caused by *Fusarium graminearum* Schwabe) and associated deoxynivalenol accumulation. Ambassador is well adapted to Michigan and Ontario, Canada, and has also produced high grain yields throughout the region. The name was chosen because Ambassador's performance excels in both the United States (Michigan) and Canada (Ontario), bringing together white-wheat growers on both sides of the border.

**Jupiter**
Soft white winter wheat

‘Jupiter’ (MSU research name E5011) is a soft white winter wheat developed at Michigan State University from the cross ‘Caledonia’ / ‘Richland’. Jupiter has exceptional yield in Michigan, good powdery mildew resistance, short stature, bronze chaff and is awnletted (very short awns). Jupiter was released from MSU in 2010. It is susceptible to Fusarium head blight (FHB), though its reaction to FHB is not statistically different (LSD 0.05) from ‘Caledonia’, the soft white winter wheat that has been predominant in Michigan for the past several years. In the 2010 Wheat Quality Council meeting, Jupiter was reported to have good biscuit and breakfast cereal qualities.

**E5024**
Soft white winter wheat

E5024 is a soft white winter wheat developed at Michigan State University from the cross MSU ‘D6234’ / Pioneer Brand ‘25W33’. It has good yield in Michigan, high test weight, is short, has white chaff and is awned. E5024 has resistance to many diseases, including improved resistance to Fusarium head blight, powdery mildew and stem rust. Data also suggest that E5024 has some improved resistance to PHS and it includes the favorable PHS tolerant allele of the *Vp1* gene.

**E6012**
Soft white winter wheat

E6012 is a soft white winter wheat developed at Michigan State University from the cross ‘Caledonia’ / Pioneer Brand ‘25W33’. E6012 has good yield in Michigan, is early maturing, of average height, has white chaff, is awned and has good resistance to stripe rust.

**Envoy**
Soft white winter wheat

‘Envoy’, experimental name MSU Line E1009, is a soft white winter wheat developed at Michigan State University (MSU). Envoy was selected from breeding population 950542, which was created from a cross in 1995 with the parentage ‘MSU Line DC076’ / ‘PIONEER 2552’. Envoy is a high yielding soft white winter wheat well adapted to Michigan and Ontario, Canada. In addition to having acceptable grain quality and good yield, Envoy has high testweight, reduced deoxynivalenol mycotoxin accumulation from Fusarium head blight (in comparison with many soft white winter wheats), and is short. Its primary weakness is susceptibility to Barley Yellow Dwarf Virus.

**Coral**
Soft white winter wheat

'Coral', experimental name MSU Line E2017, is a soft white winter wheat developed at Michigan State University (MSU). Coral was selected from breeding population 950302, which was created from a cross in 1995 with the parentage 'D3913'/'D0331'. In addition to being adapted to Michigan, having good yield and acceptable grain quality, Coral's strengths include improved resistance to Fusarium head blight (visual), and reduced levels of the Fusarium head blight mycotoxin deoxynivalenol (DON) in comparison to many other high yielding white wheats grown in MI. Furthermore, Coral has good test weight, and lacks awns. Its primary weaknesses are susceptibility to powdery mildew and stripe rust.

**MSU D8006**
Soft white winter wheat

MSU D8006 is a soft white winter wheat, is awned, and is white chaffed. MSU D8006 is moderately resistant to stripe rust and Wheat Spindle Streak Mosaic Virus and has superior milling and baking properties. Allis milling data is available from 2006, and Miag milling data is included in the Miag milling database.

**Crystal**
Soft white winter wheat

(MSU Line E0027) is a soft white winter wheat, is awned, and is white chaffed. Crystal is similar to Caledonia in height, flowering dates, and lodging resistance. Crystal is moderately resistant to Wheat Spindle Streak Mosaic Virus and powdery mildew. Miag milling data was included in the 2007 Quality Evaluation Council report.

**Ohio Seed Improvement Association**
John Armstrong

**Delta King DK 9577**
Soft red winter wheat

DK 9577 is a high yielding, medium early, widely adapted, soft red winter wheat. It is an awnless, medium stature variety that performs from Western Kentucky to Northern Louisiana. DK 9577 has solid resistance to leaf rust and powdery mildew, with moderate resistance to stripe rust and Septoria leaf blotch. It has excellent standability and winter hardiness. It is a small seeded variety with excellent test weight and performs well on all soil types.

**Delta King DK 9108**
Soft red winter wheat

DK 9108 is a very early maturing, high yielding soft red winter wheat variety with excellent early growth and grazing potential. It is an awnless, larger seeded variety with medium test weight. DK 9108 has excellent resistance to stripe rust, leaf rust, Septoria leaf blotch, and powdery mildew. It is medium tall variety with good standability. Grain yields are best in AR, MS, and LA.

**Armor GOLD**
Soft red winter wheat

Armor GOLD is a new awnletted, medium maturing soft red winter wheat variety that was made available in the fall 2008. It is a medium stature variety with excellent standability and winter hardiness. Armor GOLD has excellent yield potential across soil types, but really stands out on heavier, wetter soils. It has excellent resistance to stripe rust, leaf rust, Septoria leaf blotch, and powdery mildew. It has medium seed size with excellent test weight.

## Ohio State University

Clay Sneller

**OH04-264-58**
Soft red winter wheat

OH04-264-58 is a soft wheat with very strong gluten. Our current analyses indicate that the gluten strength of OH04-264-58 is similar to that of Pioneer 25R26 and shows stability over environments. Its gluten strength is derived in part from the Bx7oe allele at the *Glu-B1* locus. This allele produces over expression of the high molecular weight glutenins at that locus. OH04-264-58has below average quality for cakes or cookies and is best suited for crackers. OH04-264-58has short stature with good lodging resistance, tan chaff and awns. It has moderate resistance to Fusarium head blight, powdery mildew, and Stagonospora leaf and glume blotches. OH04-264-58? has been approved for release for exclusive licensing. The process for obtaining a license will be developed and distributed within the next two months.

**Malabar**
Soft red winter wheat

Ohio Certified Seed “Malabar” is a new mid-season, beardless, soft red winter wheat that offers consistent yields with high test weight and an excellent disease resistance package. It is an awnless, white chaffed variety that has medium plant height with good standability. It shows outstanding tolerance with moderate resistance to Fusarium head blight.

## Pioneer Hybrid

Bill Lasker, Greg Marshall

**Pioneer ® variety 25R32**
Soft red winter wheat

25R32 (Experimental number XW07X) is a soft red winter wheat developed by Pioneer Hi-Bred International, Inc. 25R32 is awned and on average heads one day later than 25R47. It averages about three centimeters taller than 25R47 and it has good straw lodging resistance. 25R32 has shown good winter hardiness and it joints very late in the spring, which reduces its risk of damage from spring freeze.

25R32 exhibits a high level of Fusarium head blight resistance along with excellent stripe rust and very good powdery mildew resistance. 25R32 has good resistance to Spindle Streak Mosaic and Soilborne Mosaic Viruses. It has average resistance to leaf rust and the complex of fungal organisms that incite leaf blights. 25R32 is postulated to contain the H9,H10 genes for Hessian fly resistance.

25R32 has been granted Plant Variety Protection (200900448) and U.S. Patent has been applied for.

**Pioneer ® variety 26R20**
Soft red winter wheat

26R20 (Experimental number XW07B) is a soft red winter wheat developed by Pioneer Hi-Bred International, Inc. 26R20 is awned and on average heads three days later than 25R78. It averages about four centimeters taller than 25R78 and it has very good straw lodging resistance.

26R20 has shown very good resistance to leaf rust, stripe rust, and powdery mildew. 26R20 has average resistance to Spindle Streak Mosaic and Soilborne Mosaic Viruses and the complex of fungal organisms that incite leaf blights. It has shown moderate resistance to predominant field biotypes of Hessian fly in the southeastern U.S. region. 26R20 has below average Fusarium head blight resistance.

26R20 has been granted Plant Variety Protection (200900447) and U.S. Patent has been applied for.

**Pioneer 25R39**
Soft red winter wheat

25R39 (formerly XW06M) is a soft red winter wheat that was developed by Pioneer Hi-Bred International, Inc., and it is derived from a single cross of a Pioneer experimental variety and previously released Pioneer variety, using a modified pedigree selection breeding method. 25R39 is primarily intended for grain production and it has shown good adaptation to the soft winter wheat region based on tests conducted in Arkansas, Kentucky, Missouri, Illinois, Indiana, Ohio, Michigan, Maryland and Ontario, Canada.

25R39 is awnless and heads about one day later than 25R47 on average. It has shown very good winter hardiness and moderate resistance to straw lodging. It has demonstrated excellent resistance to leaf rust and stripe rust and moderate resistance to powdery mildew. It has also shown moderate resistance to the complex of fungal organisms that incite leaf blights. It also exhibits moderate resistance to wheat spindle streak and soil borne wheat mosaic viruses.

**Purdue University**
Herb Ohm

**INW0731 (P99608C1-1-3-4)**
Soft red winter wheat

Parentage:
Sunset/Pioneer2571/3/Clark//Roazon/Caldwell/4/VPM1/Moisson//Clark/3/Clark*2/Caldwell/9/Caldwell*2/PioneerS76/8/Beau*2/Potomac//Auburn/Caldwell*2/7/Benhur/Arthur/6/Laporte/Konx*2/5/Hart/Beau/4/Arthur/3/Monon//Funo/Knox/10/Freedom/Fundulea201R. After the last cross, plant selections were made in F2, F3 and F4, with the pedigree method of selection, and INW0731 is the progeny of a single F4 plant. Off-type plants in an initial F4:8 seed increase plot in 2005 were discarded.

INW0731 soft red winter wheat (*Triticum aestivum* L.) was developed cooperatively by the Purdue University Agriculture Research Programs and the USDA-ARS, and was released by Purdue University Agriculture Research Programs in 2007. INW0731 was released for its high yield, excellent soft wheat milling and baking qualities, moderate resistance to yellow dwarf, Fusarium head blight, leaf rust, powdery mildew, *Stagonospora nodorum* blotch, Septoria leaf blotch, Soilborne Mosaic Virus, and Wheat Spindle Streak Mosaic Virus. INW0731 is susceptible to prevalent biotypes of Hessian fly, and prevalent races of stripe rust and stem rust in Indiana.

It is adapted to Indiana, especially southern Indiana and adjacent regions, and has survived winters and performed well in northern Indiana, but winters have been mild since 1996. In multilocation trials in Indiana, 2004 – 2007 (20 year-location tests) average grain yield (kg/ha, Lsd 0.05 = 497) of cultivars INW0731, Pioneer25R47, Roane, and Patterson were 6480, 6527, 5868 and 5539, respectively, and their test weights (kg m-3, Lsd 0.05 = 21.9) were 775, 736, 789 and 773, respectively. In the Uniform Eastern Soft Winter Wheat Regional Nursery in 2006, INW0731 averaged 5586 kg/ha at 29 location tests, and ranked 24th of 46 entries. INW0731 ranked higher, even 1st of 46 entries at drier locations. In multilocation trials in Indiana in 2007, a season with significant drought conditions and moderate yellow dwarf infection, INW0731 excelled for grain yield, ranking 1st of 90 entries.

INW0731 is moderately early, heading typically on day 134 julian, one day later than ‘Patterson’ at Lafayette, Indiana. Plant height of INW0731 is mid tall, typically 91 cm. The coleoptile of INW0731 is colorless and seedling anthocyanin is absent. Plant color is green at booting and anthers are yellow. The stem does not have anthocyanin. Stem internodes are hollow, and hairs of the last internode are absent. Spikes are awnless, fusiform and lax, and are inclined at maturity. Glumes are glabrous, mid-long, mid-wide and white at maturity. Kernels are mid-long and elliptical, the brush is short and not collared, and cheeks are rounded. The crease is mid-wide and mid-deep. Juvenile plant growth is semi-erect.

## Rupp Seeds

John King

**RS967**
Soft red winter wheat

Grain yield: very high yielding line
Winter hardiness: very good
Lodging resistance: very good
Disease resistance: Resistant to head scab, Moderate Resistance to powdery mildew
Morphology: awned,
Plant height: medium
Heading date: medium
Status of breeder seed: released in 2009

**RS935**
Soft red winter wheat

Grain yield: very high yielding line
Winter hardiness: very good
Lodging resistance: very good
Disease resistance: Moderate Resistance to head scab and powdery mildew
Morphology: awned
Plant height: medium
Heading date: medium early
Status of breeder seed: released in 2009

**RS953**
RS953, Rupp Seeds: Maturity – Medium-Early, Head Type – Awnless, Test Weight – Heavy, Height – Medium, Standability – Excellent, Disease Resistance – head scab (MR), powdery mildew (MR), Septoria (MR).

**RS978**
RS978, Rupp Seeds: Maturity – Early, Head Type – Awnless, Test Weight – Heavy, Height – Medium-Tall, Standability – Excellent, Disease Resistance – head scab (MS), powdery mildew (MR), Septoria (MR).

**RS908**
RS908, Rupp Seeds Maturity – Early, Head Type – Awnless, Test Weight – Heavy, Height – Medium, Standability – Excellent, Disease Resistance – head scab (MS), powdery mildew (MR), Septoria (R).

## Seed Consultants
Bill Mullen

**SC 1301**
Soft red winter wheat

SC1301 Grain yield: above average yields of 80 bushel in research testing.
Winter hardiness: very good
Lodging resistance: good
Disease resistance: exceptional tolerance to stripe rust, powdery mildew and head scab, only average tolerance to *Septoria tritici*.
Quality characteristics: test weight consistently above 60 pounds; on siemer milling premium list.
Morphology: smooth head type.
Plant height: 37”
Heading date: early variety, per Julian maturity, 111.
Status of breeder seed: 3 years of testing, released in 2010.

**SC 1311**
Soft red winter wheat

Grain yield: consistently above average yields in producer fields.
Winter hardiness: very good
Lodging resistance: very good
Disease resistance: excellent tolerance to head scab, powdery mildew and glume blotch; average tolerance to *Septoria tritici* and leaf rust.
Quality characteristics: very high test weight
Morphology: awnless
Plant height: 37”
Heading date: medium early variety, per Julian maturity, 112.
Status of breeder seed: 3 years testing, released in 2010.

**SC1321**
Soft red winter wheat

SC1321 is a very high yielding variety, in 2010 Kentucky wheat trials SC 1321 was 6th out of 83 entries in summary of 5 location trials.
Winter hardiness: very good
Lodging resistance: excellent

Disease resistance:  very good tolerance to leaf rust, powdery mildew, and glume blotch; average tolerance to *Septoria* and head scab.
Quality characteristics:  above average test weight.
Morphology:  awned
Plant height:  33”
Heading date:  medium early variety, per Julian maturity, 112.
Status of breeder seed:  3 years testing, released in 2010.

**SC1341**
Soft red winter wheat

SC 1341 grain yield:  in 2010 Kentucky wheat trial, 5 location summary, SC 1341 was 25th  at 87.5 bushel; 2010 OH wheat trial, 5 location summary, SC 1341 was 11th at 76.7 bushel.  Very high yielding line.
Winter hardiness:  very good
Lodging resistance:  excellent
Disease resistance:  very good tolerance to head scab, *Septoria tritici*, and stripe rust; average tolerance to powdery mildew.
Quality characteristics:  above average test weight.
Morphology:  awned
Plant height:  33”
Heading date:  medium late variety, per Julian maturity, 114.
Status of breeder seed:  3 years testing, 2010 release.

**Steyer seed**
Joe Steyer

**Ashlyn**
Soft red winter wheat

Grain yield:   Excellent
Winter hardiness:  Excellent
Lodging resistance:  Excellent
Disease resistance:  Moderate resistance to leaf rust, stripe rust, powdery mildew, septoria leaf blotch, septoria glume blotch, fusarium head blight
Morphology:   Awned
Plant height:   Medium
Heading date:  Medium
Status of breeder seed:    Released in 2010, 2 years of testing, 200 acres seed production

**Geary**
Soft red winter wheat

Geary is a soft red, awnless winter wheat with medium height and maturity, excellent standability and winter hardiness as well as good test weight.  Geary is broadly adapted to soils and environment, has good pest resistance to glume blotch, leaf blotch, leaf rust and Soil Borne Mosaic Virus.

**Jordan**
Soft red winter wheat

Jordan is a soft red, awnless winter wheat with medium height and medium to early maturity. Jordan has an excellent test weight and very good standability and winter hardiness. This is a very high yielding variety with an excellent disease package. Jordan is resistant to stem rust, leaf rust, glume blotch, leaf blotch, Soil Borne Mosaic Virus, Barley Yellow Dwarf and Hessian fly and has good resistance to powdery mildew.

**Kenton**
Soft red winter wheat

Kenton is a soft red, awnless winter wheat with tall height and late maturity. Kenton has some resistance to pests, aggressive tillering and is excellent for straw. It is a high yielding variety with heavy test weight and excellent winter hardiness and standability.

**Kidwell**
Soft red winter wheat

Grain yield: excellent
Winter hardiness: Excellent
Lodging resistance: Excellent
Disease resistance: Moderate resistance to leaf rust, stripe rust, septoria leaf blotch, septoria glume blotch, fusarium head scab.
Morphology: Awned
Plant height: Med-short
Heading date: Med-early
Status of breeder seed: New release in 2011, 2 years testing, 250 acres seed production.

**Kingen**
Soft red winter wheat

Grain yield: Excellent
Winter hardiness: Excellent
Lodging resistance: Excellent
Disease resistance: Moderate resistance to powdery mildew,stripe rust, leaf rust, Septoria leaf blotch
Quality characteristics: Good milling and baking qualities
Morphology: Awnless
Plant height: Med-tall
Heading date: Early
Status of breeder seed: Released in 2008, 4 years testing, 300 acres seed production.

**Marion**
Soft red winter wheat

Grain yield: Excellent
Winter hardiness: Very good
Lodging resistance: Very good
Disease resistance: Highly resistant to powdery mildew, moderate resistance to Fusarium head blight, Septoria leaf blotch, Septoria glume blotch.
Morphology: Awnless
Plant height: Medium
Heading date: Medium
Status of breeder seed: Released 2010, 3 years of testing, 300 acres seed production.

**Merrell**
Soft red winter wheat

Merrell is a soft red, awnless winter wheat with medium height and medium to early maturity. Merrell has an excellent test weight and very good standability and winter hardiness. This is an early, high yielding variety with excellent winter hardiness and wonderful standability and good disease resistance. Merrell was #1 in 2006 Penn State Wheat Trials.

**Moral**
Soft red winter wheat

Moral is a soft red, awnless winter wheat with short height and medium maturity. Moral has an excellent test weight and superb powdery mildew resistance. Moral produces consistent yields over varied environments.

**Quin-lee**
Soft red winter wheat

Class: Soft red winter, broadly adapted
Grain yield: Excellent
Winter hardiness: Excellent
Lodging resistance: Excellent
Disease resistance: Resistant to leaf rust, powdery mildew, septoria leaf blotch, mr to fusarium head blight, septoria glume blotch
Quality characteristics: Excellent milling and baking characteristics
Morphology: Awned
Plant height: Medium
Heading date: Medium
Status of breeder seed: Released in 2010, 3 years testing, 130 acres of seed production

**Wiley**
Soft red winter wheat

Wiley is a soft red, awnless winter wheat with medium height and medium to early maturity. Wiley has an excellent test weight. This is an early, high yielding variety with excellent winter hardiness and wonderful standability and good disease resistance. Wiley is a top end yield combined with exceptional bucket weight. Its early maturity makes it ideal for double cropping. This variety has the complete package, disease resistance, yield and test weight.

**Sunbeam Extract Company**
Howard Lafever

**Sunburst**
Soft red winter wheat

Sunburst is a soft red winter wheat (Triticum aestivum L.) developed by the Sunbeam Extract Company of Wooster, Ohio. Sunburst is widely adapted to the Eastern Corn Belt, more specifically to Ohio, Michigan, Pennsylvania and parts of Canada. Sunburst is intended for the general-purpose wheat market.

Sunburst originated from the cross Taishang1/GR863//Cardinal, made in Wooster, Ohio in 1991, and was designated as SE91-1942-4. Sunburst has blue-green head color, an erect-twisted flag leaf, short height, excellent straw strength and is awnless. Green stage variants include: 0.05% yellow green tall, 0.05% yellow reen, 0.05% yellow green awned, 0.35% yellow green, 0.6% tall awned, 0.1% tall for a combined variant total of 0.6%.

Sunburst was selected due to its excellent winter hardiness, excellent test weight, high yield potential, good scab resistance and leaf stripe resistance. Ohio Foundation seed will maintain breeder seed. The Certified classes of seed will be Foundation, Registered and Certified.

**Syngenta**
June Hancock

**Arcadia**
Soft red winter wheat

Arcadia is a white-chaffed soft red winter wheat bred and developed by Syngenta Seeds, Inc. It was initially tested as D05*6441. It is an early maturing, short height semi-dwarf with good test weight patterns. It has moderate resistance to moderate susceptibility to prevalent races of leaf rust and stripe rusts. Arcadia is susceptible to powdery mildew and Hessian fly. Arcadia is moderately susceptible to *Septoria tritici*. Arcadia has good milling and baking qualities. This variety is intended for grain production.

Yield testing of Arcadia was initiated in the 2005-2006 season at the F7 generation at 13 locations in the Southern US. Advanced and elite yield testing has been conducted since this time. In 2007 Arcadia was tested at 24 locations and since has been tested in up to 28 locations to determine that Arcadia is adapted to the deep south in the Delta and the East Coast areas. The cross was selected for height, appearance, maturity, and kernel soundness using a bulk breeding method. In 2009, Arcadia was entered in the USDA Uniform Southern Soft Red Winter Wheat Nursery, and Arcadia (as D04*6441) was tested in state-run official wheat trials in Arkansas, Louisiana, Mississippi, Alabama, and Georgia in 2009-2010.

Arcadia has a juvenile growth habit that is semi-erect. Plant color at boot stage is dark green. Flag leaf at boot stage is erect and twisted. Auricle anthocyanin and auricle hairs are present. Waxy bloom is present on the head, stem and flag leaf sheath. Anther color is yellow. Head shape is tapering, middense and awned. Glumes are glabrous, midwide in width and long in length with wanting shoulders and acuminate beaks. Chaff color is white in color. Seed shape is ovate. Seed cheek is rounded. Seed crease depth is shallow and seed crease width is narrow.

**SY 9978**
Soft red winter wheat

SY 9978 is a white-chaffed soft red winter wheat bred and developed by Syngenta Seeds, Inc. It is a medium maturing, medium tall height semidwarf with good test weight patterns. It has good resistance to powdery mildew, Hessian fly and stripe rust. SY 9978 has shown moderate resistant to moderate susceptibility to leaf rust and *Septoria tritici*. Milling and baking characteristics are good. This variety is intended for grain production.

Yield testing of SY 9978 was initiated in the 2004-2005 season at the F8 generation at 4 locations in the Southern US. Advanced and elite yield testing has been conducted since this time. In 2007 Arcadia was tested at 24 locations and since has been tested in up to 28 locations to determine that Arcadia is adapted to the upper Delta and the northern East Coast areas. The cross was selected for height, appearance, maturity, and kernel soundness using a bulk breeding method. In 2009, SY 9978 was entered in the USDA Uniform Southern and Eastern Soft Red Winter Wheat Nursery and SY 9978 (as B040798*) was tested in state-run official wheat trials in Arkansas, Missouri, Tennessee, Kentucky, Alabama, North Carolina, Virginia, Delaware, and Pennsylvania in 2009-2010.

SY 9978 has a juvenile growth habit that is semi-erect. Plant color at boot stage is blue green. Flag leaf at boot stage is erect and twisted. Auricle anthocyanin and auricle hairs are present. Waxy bloom is present on the head, stem and flag leaf sheath. Anther color is yellow. Head shape is tapering, mid-dense and awned. Glumes are glabrous, wide in width and long in length with oblique shoulders and acuminate beaks. Chaff color is white in color. Seed shape is ovate. Seed cheek is rounded. Seed crease depth is shallow and seed crease width is narrow.

**Oakes**
Soft red winter wheat

Oakes (03JH000543 or B030543) is a soft red winter wheat bred and developed by Syngenta Seeds, Inc. for grain production. Oakes was derived from a head that was selected in spring of 2001 from a composite F5 bulk population that included a single cross made by Syngenta Seeds, Inc. personnel in the greenhouse at Bay, AR in the spring of 1996. This variety is intended for grain production with grain yield data that indicates it is adapted to most of the mid-south, delta and eastern coast soft wheat areas.

Oakes is resistant to moderately resistant to stripe rust field races prevalent in 2006, 2007 and 2008. Oakes has shown moderate resistance to moderate susceptibility to leaf rust field races prevalent in the mid-south and southeastern US in 2006, 2007 and 2008. Oakes is moderately susceptible to susceptible to powdery mildew in the southeast. Oakes is moderately resistant to moderately susceptible to Wheat Spindle Streak Virus, Soil Borne Mosaic Virus and *Septoria tritici*. Oakes is susceptible to Hessian fly.

Oakes is medium-height wheat with medium season heading. Oakes in 2006 was 84 cm, and in 2008 Oakes was 94 cm which was the same height as Beretta in both years averaging 89 cm. Oakes averages two days earlier than Beretta. Oakes headed four days earlier than Beretta in 2006, and in 2008 it headed one day earlier than Beretta. Juvenile growth habit is semierect. Plant color is green at boot stage. Flag leaf at boot stage is recurved and twisted. Waxy bloom is present on the head, stem and flag leaf sheath. Anther color is yellow. Head shape is tapering and apically awnletted. Glumes are medium in width and short in length with oblique shoulders and obtuse beaks. Seed shape is ovate. Brush hairs are medium in length. Seed cheeks are rounded.

**SY 1526**
Soft red winter wheat

SY 1526 is a soft red winter wheat, bred and developed by Syngenta Cereals for grain production. SY 1526 is a medium tall, semi-dwarf variety and has white chaff at maturity. It has medium early maturity and its heading is less than a day later than Branson's. SY 1526 has shown best adaptation to the area south of Interstate 70 in the states of Illinois, Indiana, Ohio, and Kentucky and appears to be suitable for double-cropping in this region. It has shown moderate resistance to the races of leaf rust in this area, and moderate susceptibility to Soil Borne Mosaic Virus. Based on observations and data from southern Illinois in 2009, it may be resistant to Wheat Spindle Streak Mosaic Virus.

SY 1526 has shown acceptable milling and cookie baking properties in three years of testing.

## UniSouth Genetics, Inc.
Stacy Burwick

**USG 3555**
Soft white winter wheat

USG3555 is an early maturing, short awnletted soft white winter variety with fair test weight. It is resistant to biotype E Hessian fly and has a widely adapted production area. USG3555 can be planted later to avoid Hessian fly, and its maturity is similar to USG 3209. Field ratings are excellent standabililty, very good emergence and good winter hardiness. Planting rate is 1.5 mil./ac. USG3555 has very good resistance to stem and stripe rusts and to powdery mildew, and good resistance to Barley Yellow Dwarf Virus.

On the basis of milling and baking quality data for four crop years (2003-2006), USG 3555 tends to have higher break flour yields and slightly softer texture than USG 3209. Flour yields of USG 3555 have been similar to those of USG 3209. On average USG 3555 has higher grain protein concentration and stronger gluten strength than USG 3209. Overall, USG 3555 has better pastry baking quality on the basis of lower values for sucrose retention capacity and larger cookie diameters than USG 3209, and also has good cake baking qualities.

**USG 3665**
Soft red winter wheat

USG 3665 is a medium to late maturing, medium height, awnless variety with great test weight. USG3665 is resistant to stripe and leaf rust, and adapted to all soil types. Field ratings are very good winter hardiness and standability, and good emergence. Planting rate is 1.4 Mil./Ac. USG3665 has moderate resistance to glume blotch, Barley Yellow Dwarf Virus, and SBMV, and some resistance to powdery mildew and Scab.

## University of Georgia
Jerry Johnson

**USG 3295**
Soft red winter wheat

USG 3295 (GA951395-3E25) is a medium-late maturing, awnless soft red winter wheat with white chaffed and short in height with excellent test weight. It was derived from the cross, GA 87110 / VA93-52-55// GA 88151. The pedigree of GA 87110 is GA-Andy / GA-Gore; VA 93-52-55 is Massey*3 / Balkan//Saluda; and GA 88151 is Hunter // FengKang 7 / GA-Gore. GA 88151 / Hickory//AGS 2000. Its maturity is 3 days later than AGS 2000. USG 3295 is resistant to races of leaf rust and stripe rust in the southeast U.S. It is also resistant to Soil-borne Mosaic Virus and powdery mildew. It is susceptible to current biotypes of Hessian fly in Georgia. USG 3295 has excellent milling and baking quality. USG 3295 is equal to Patton in flour yield (71.5% vs 70.6%), equal in softness equivalent score (51.2% vs 54.9%), lower flour protein (8.7% vs 9.2%), and equal in lactic acid retention (95% vs 93%).

**BALDWIN**
Soft red winter wheat

BALDWIN (GA 981621-5E34) is a medium-late maturing, awned soft red winter wheat and medium in height with excellent test weight. It was derived from the cross, AGS 2485 and PIO26R61. It maturity is 3 days later than AGS 2000. Baldwin is resistant to races of leaf rust and stripe rust in the southeast U.S. It is also resistant to Soil-borne Mosaic Virus and powdery mildew, and resistant to current biotypes of Hessian fly in Georgia. Baldwin has excellent milling and baking quality. Baldwin is equal to AGS 2000 in flour yield (72.0% vs 71.7%), higher in softness equivalent score (60% vs 56%), equal in flour protein (8.6% vs 8.6%), equal in lactic acid retention (108% vs 107%) and equal in sucrose retention capacity (90% vs 90%).

**AGS 2020 (GA 991336-6E9)**
Soft red winter wheat

AGS 2020 (GA 991336-6E9) is a medium maturing soft red winter wheat that is white chaffed and medium in height. It was derived from the cross GA92432 // AGS 2000 / PIO 26R61. It is similar to AGS 2000 in maturity. GA 991336-6E9 is widely adapted in the Deep South and mid-South area. GA 991336-6E9 is resistant to current biotypes of Hessian fly in Georgia and is resistant to races of leaf rust and stripe rust in the southeast U.S. It is also resistant to Soil-borne Mosaic Virus and powdery mildew.

AGS 2020 has good milling and baking quality which is similar to AGS 2000. GA 991336-6E9 is equal to AGS 2000 in flour yield (72.6% vs. 73.1%), lower in softness equivalent score (54.9% vs. 58.9%), higher in flour protein (9.6% vs. 8.9%), slightly lower in lactic acid retention (103% vs. 113%) and equal in sucrose retention capacity (95% vs. 94%).

**USG 3120 (GA 991209-6E33)**
Soft red winter wheat

USG 3120 is a medium maturing soft red winter wheat that is white chaffed and medium in height. It was derived from the cross GA 901146 / GA 9006 // AGS 2000. Its maturity is two days earlier than AGS 2000. GA 991209-6E33 has excellent resistant to current biotypes of Hessian fly in Georgia, including biotype L, and is resistant to races of leaf rust and stripe rust. It is also resistant to Soil-borne Mosaic Virus and susceptible to powdery mildew.

GA 991209-6E33 has good milling and baking quality which is similar to AGS 2000. GA 991209-6E33, in comparison to AGS 2000, is equal in flour yield (71.9% vs. 73.1%), slightly lower in softness equivalent score (56.8% vs. 58.9%), equal in flour protein (8.3% vs. 8.9%), slightly lower in lactic acid retention (102% vs. 113%) and equal in sucrose retention capacity (91% vs. 94%).

**GA 991371-6E12**
Soft red winter wheat

GA 991371-6E12 is a medium maturing soft red winter wheat that is white chaffed and medium in height. It was derived from the cross GA 931521 / *2 AGS 2000. It is similar to AGS 2000 in maturity. GA 991371-6E12 is moderately resistant to current biotypes of Hessian fly in Georgia, including biotype L, and is resistant to races of leaf rust (Lr37) and stripe rust (Yr17). It is also resistant to Soil-borne Mosaic Virus and susceptible to powdery mildew.

GA 991371-6E12 has good milling and baking quality which is similar to AGS 2000. GA 991371-6E12, in comparison to AGS 2000, is equal in flour yield (71.9% vs. 73.1%), equal in softness equivalent score (57.5% vs. 59.7%), equal in flour protein (8.9% vs. 9.1%), equal in lactic acid retention (115 vs. 110%) and equal in sucrose retention capacity (93% vs. 98%).

## Virginia Polytechnic Institute

Carl Griffey

**VA05W-139**
Soft red winter wheat

The soft red winter wheat line VA05W-139 was derived from the cross Pioneer Brand ‘26R24’ (PI 614110 PVPO) / ‘McCormick’ (PI 632691). VA05W-139 was evaluated in seven environments over three years (2008 – 2010) in Virginia’s State Variety Trials, and was evaluated throughout most of the soft red winter (SRW) wheat region in the USDA-ARS Uniform Southern Soft Red Winter Wheat Nurseries in 2009 and 2010. VA05W-139 is widely adapted, has short plant height, very good straw strength, and high grain yield potential. VA05W-139 has expressed moderate to high levels of resistance to the most prevalent wheat diseases in the eastern U.S. with the exception of stem rust and Hessian fly. Most notably, VA05W-139 provides producers in the eastern U.S. with a cultivar having adult plant resistance to stripe rust. It is expected that 1200 Bu of Foundation seed will be produced in 2011, which will be available for distribution to seedsmen.

VA05W-139 is a short height semi-dwarf (gene *Rht*2) that is full-season maturity, resistant to lodging, broadly adapted, and high yielding. In the southern SRW wheat region, average head emergence of VA05W-139 (118 – 120 d) has been 4 to 6 days later than ‘Coker 9553’. Mature plant height of VA05W-139 is 31 to 34 inches and on average is 0.6 inch taller than ‘USG 3555’ and 2 to 3 inches shorter than Coker 9553.

On average, straw strength (0=erect to 9=completely lodged) of VA05W-139 (0.2 – 0.9) is better than that of USG 3555 (1.2 – 1.8). VA05W-139 was evaluated at 26 locations in the 2009-10 USDA-ARS Uniform Southern SRW Wheat Nursery (USSRWWN), and ranked seventh among 32 entries for grain yield (64.5 Bu/ac). VA05W-139 had a mean test weight (56.8 Lb/Bu) that was most similar to that of USG 3555. VA05W-139 ranked among the top ten entries for grain yield at 15 of the 26 locations. VA05W-139 also was evaluated at 25 locations in the 2008-09 USSRWWN, and ranked fourth among 40 entries for grain yield (68.7 Bu/ac). VA05W-139 ranked among the top ten entries at 12 of the 25 locations. In comparison to the four check cultivars, VA05W-139 produced an average test weight (55.1 Lb/Bu) that was most similar to that of USG 3555. On the basis of winter kill ratings (0 = no injury to 9 = complete kill) reported at 3 of 25 locations in the 2008-09 USSRWWN, winter hardiness of VA05W-139 (3.9) was similar to that of Coker 9553 (4.0), and better than 'AGS 2000' (5.2) and Pioneer '26R61' (5.5).

Grain samples of VA05W-139 produced in six crop environments (2008 – 2010) were evaluated for end use quality by the USDA-ARS Soft Wheat Quality Lab. VA05W-139 has exhibited milling and baking qualities that are most similar to those of the strong gluten cultivar Coker 9553. Mean comparisons of milling and baking quality attributes of VA05W-139 versus Coker 9553 include: milling quality scores (60.6 vs. 63.1), baking quality score (37.7 vs. 53.9), softness equivalent score (58.9 vs. 68.0), flour yield (68.0% vs. 68.6%), and flour protein (8.64% vs. 8.92%). Gluten strength of VA05W-139 as predicted by lactic acid solvent retention capacity has been consistently higher (mean of 138.8%) than that of Coker 9553 (mean of 121.3%) and other cultivars. VA05W-139 had lower cookie spread diameters (17.8 – 18.1 cm) compared with Coker 9553 (18.3 – 18.7 cm), 'Shirley' (19.59 cm), and AGS 2000 (18.8 – 19.1 cm). While flour solely derived from VA05W-139 is not desirable for pastry production, it's very strong gluten flour may be desirable for use in production of leaven products such as crackers and certain breads as well as in blends with flour derived from weak gluten cultivars to improve their functionality.

**VA05W-151**
Soft red winter wheat

The soft red winter wheat line VA05W-151 was derived from the cross Pioneer Brand '26R24' (PI 614110 PVPO) / 'McCormick' (PI 632691). VA05W-151 was evaluated in seven environments over three years (2008-2010) in Virginia's State Variety Trials, and was evaluated throughout most of the soft red winter (SRW) wheat region in the USDA-ARS Uniform Eastern Soft Red Winter Wheat Nurseries in 2009 and 2010. VA05W-151 is a widely adapted, early heading wheat cultivar that has high grain yield potential and high test weight. VA05W-151 has expressed moderate levels of resistance to the most prevalent wheat diseases in the eastern U.S. with the exception of stripe rust and Hessian fly. An initial seed purification of VA05W-151 was sown on five acres at the VCIA Foundation seed farm during fall 2010 and is expected to produce 400 bu of Foundation seed. Breeder seed also was planted on 1 acre during fall 2010 and is expected to produce at least 80 bu of Foundation seed.

The soft red winter wheat line VA05W-151 is a broadly adapted, high yielding, early maturing, short height semi-dwarf (gene Rht2). In the eastern SRW wheat region, average head emergence of VA05W-151 (129 – 135 d) has been similar to ‘Branson’ (129 – 134 d) and 2 to 3 d earlier than ‘Shirley’ and ‘Roane’. Mature plant height of VA05W-151 is 33 to 34 inches and on average is similar to Branson, 1 to 2 inches taller than Roane and Shirley, and 2.5 inches shorter than ‘Bess’. On average, straw strength (0=erect to 9=completely lodged) of VA05W-151 (2.6 – 3.4) is most similar to that of ‘Featherstone 176’ (3.1) and Roane (3.2), but weaker than that of Branson (1.3 – 2.0). VA05W-151 was evaluated at 27 locations in the 2009-10 USDA-ARS Uniform Eastern SRW Wheat Nursery (UESRWWN), and produced the highest mean grain yield (72.9 Bu/ac) and second highest test weight (59.4 Lb/Bu) among 46 entries. Grain yields of VA05W-151 were significantly ($P < 0.05$) higher than the test averages at 11 of the 27 locations and ranked among the top ten entries at 20 locations. VA05W-151 also was evaluated at 28 locations in the 2008-09 UESRWWN, and ranked first among 42 entries for grain yield (83.2 Bu/ac) and second for test weight (59.1 Lb/Bu). Grain yields of VA05W-151 were significantly ($P < 0.05$) higher than the test averages at 9 of the 28 locations and ranked among the top ten entries at 20 locations. On the basis of winter kill ratings (0 = no injury to 9 = complete kill) reported at 5 of 28 locations in the 2008-09 UESRWWN, winter hardiness of VA05W-151 (2.1) was similar to that (2.2 – 2.4) of the check cultivars INW0411, Branson and Bess.

Grain samples of VA05W-151 produced in four crop environments (2008 and 2009) were evaluated for end use quality by the USDA-ARS Soft Wheat Quality Lab. VA05W-151 has exhibited milling and baking qualities that are most similar to those of the strong gluten cultivars Pioneer 26R12, USG 3315, and Tribute; although, VA05W-151 has notably higher gluten strength than these cultivars. Mean comparisons of milling and baking quality attributes of VA05W-151 versus Tribute over two years (2008-2009) include: milling quality score (69.3 vs. 69.6), baking quality score (59.0 vs. 54.4), softness equivalent score (70.3 vs. 65.9), flour yield (70.4% vs. 70.2%), flour protein (7.9% vs. 7.4%), gluten strength (lactic acid retention capacity 120.2 vs. 107.3), and cookie spread diameter (18.64 vs. 18.50 cm). On the basis of quality evaluations conducted on entries in the 2010 and 2009 UESRWWN, VA05W-151 had milling quality scores (69.6 and 64.1) that were similar to those of check cultivars Bess, INW0411, and Shirley (60.1 – 65.5) and higher than that of Roane (57.3). Baking quality scores of VA05W-151 (61.3 and 45.7) were similar to Shirley and better than INW0411 in 2010, but were lower than those of the check cultivars (52.6 – 79.8) in 2009. Softness equivalent scores of VA05W-151 (62.6 and 59.0) were most similar to those of Bess (65.5 and 57.3). Flour yields of VA05W-151 (71.0% and 70.4%) were higher than those of Bess (68.9% and 69.5%) and Roane (68.8%). Flour protein concentration of VA05W-151 (8.5% and 8.8%) was most similar to that of INW0411 (8.6% and 8.9%). Protein gluten strength of VA05W-151 estimated by lactic acid solvent retention capacity (112.8% and 114.7%) was consistently higher than that of INW0411, Branson, Bess, and Shirley (85.4% – 109.5%). Cookie spread diameters of VA05W-151 (18.6 and 18.4 cm) were similar to those of INW0411.

**VA05W-251**
Soft red winter wheat

The soft red winter wheat line VA05W-251 was derived from the cross VA98W-130 // VA96W-348 / Pioneer Brand '26R61' (PI 612153 PVPO). Parentage of VA98W-130 is 'Savannah' (PI559929) / VA87-54-558 // VA88-54-328 / 'GA-Gore' (PI 561842). Parentage of VA87-54-558 is 'Massey' (CItr 17953) / 'Holley' (CItr 14579) and parentage of VA88-54-328 is 'Lovrin 29' (PI 519144) / 'Tyler' (CItr 17899) // 'Redcoat' (CItr 13170) *2 / 'Gaines' (CItr 13448). Parentage of VA96W-348 is IN81401A1-32-2 / 'FFR555W' (PI 560318 PVPO), and parentage of IN81401A1-32-2 is 'Arthur 71' (CItr 15282) / 'Caldwell' (CItr 17897) /4/ Arthur 71 /3/ 'Benhur' (CItr 14054) // 'Riley' (CItr 13702) *2 / W62-63-119A.

VA05W-251 was evaluated in seven environments over three years (2008 – 2010) in Virginia's State Variety Trials, and was evaluated throughout most of the soft red winter (SRW) wheat region in the USDA-ARS Uniform Southern Soft Red Winter Wheat Nurseries in 2009 and 2010. VA05W-251 is widely adapted, has short plant height, high grain yield potential, and good milling and pastry baking quality. VA05W-251 has expressed moderate to high levels of resistance to the most prevalent wheat diseases in the eastern U.S. with the exception of stripe rust and stem rust. Most notably, VA05W-251 provides producers in the eastern U.S. with a cultivar having resistance to leaf rust and glume blotch. Breeder seed of VA05W-251 was planted on 8 acres during fall 2010 and is expected to produce at least 640 Bu of Foundation seed in 2011, which will be available for distribution to seedsmen.

VA05W-251 is a short height semi-dwarf (gene Rht2) that is mid-season maturity, broadly adapted, and high yielding. In the southern SRW wheat region, average head emergence of VA05W-251 (114 – 118 d) is similar to that of Pioneer Brand 26R61 and one day later than 'AGS 2000'. Mature plant height of VA05W-251 (31 – 34 inches) is similar to that of 'USG 3555' and 4 to 5 inches shorter than Pioneer Brand 26R61. Straw strength (0=erect to 9=completely lodged) of VA05W-251 (1.7 – 3.4) is equal to or slightly less than average. In Virginia's State Variety Trials, VA05W-251 had a three year (2008-2010) average grain yield (84 Bu/ac) similar ($P < 0.05$) to that of the highest yielding cultivar Shirley. VA05W-251 had a three year average test weight (58.0 Lb/Bu) that was significantly ($P < 0.05$) higher than Shirley (57.0 Lb/Bu). VA05W-251 was evaluated at 26 locations in the 2009-2010 USDA-ARS Uniform Southern SRW Wheat Nursery (USSRWWN), and produced a grain yield (61.8 Bu/ac) that was similar to the nursery average. VA05W-251 had a mean test weight (55.9 Lb/Bu) that was most similar to that of USG 3555. VA05W-251 ranked among the top ten entries for grain yield at 11 of the 26 locations. VA05W-251 also was evaluated at 25 locations in the 2008-09 USSRWWN, and ranked seventh among 40 entries for grain yield (67.1 Bu/ac). VA05W-251 ranked among the top ten entries at 13 of the 25 locations. In comparison to the four check cultivars, VA05W-251 produced an average test weight (54.7 Lb/Bu) that was most similar to that of USG 3555. On the basis of winter kill ratings (0 = no injury to 9 = complete kill) reported at 3 of 25 locations in the 2008-09 USSRWWN, winter hardiness of VA05W-251 (4.2) was similar to that of USG 3555 (4.3) and ‘Coker 9553’ (4.0).

Grain samples of VA05W-251 produced in six crop environments (2008 – 2010) were evaluated for end use quality by the USDA-ARS Soft Wheat Quality Lab. VA05W-251 has exhibited good milling and pastry baking qualities and overall has superior quality compared to USG 3555. Mean comparisons of milling and baking quality attributes of VA05W-251 versus USG 3555 include: milling quality score (68.3 vs. 65.7), baking quality score (61.0 vs. 47.4), softness equivalent score (58.3 vs. 62.1), flour yield (69.7% vs. 69.0%), and flour protein (8.2% vs. 8.7%). Gluten strength of VA05W-251 as predicted by lactic acid solvent retention capacity has been consistently lower (mean of 100.7%) than that of USG 3555 (116.1%). VA05W-251 has consistently produced cookies of larger diameter (mean of 18.76 cm) than USG 3555 (18.30 cm).

**MERL**
Soft red winter wheat

The soft red winter wheat cultivar MERL, previously designated VA03W-412, was developed and released by the Virginia Agricultural Experiment Station in March 2009. MERL was derived from the three-way cross ‘Roane’ / Pioneer Brand ‘2643’ // ‘38158’ (PI 619052=SS 520). MERL has been evaluated in Virginia’s Official State Variety Trial (http://www.grains.cses.vt.edu/) since 2005, and was evaluated throughout most of the soft red winter wheat region in the USDA-ARS Uniform Eastern Soft Red Winter Wheat Nursery from 2006 to 2008 (http://www.ars.usda.gov/main/docs.htm?docid=2925). MERL is widely adapted and provides producers and end users in the mid to deep South, mid-Atlantic, southern Corn Belt, and Northeastern regions of the U.S. with a cultivar that has high yield potential and good milling and pastry baking qualities. Foundation seed of MERL was first distributed to seedsmen in fall 2009, and limited amounts of certified seed is available for growers. Marketing and distribution of MERL is being directed by the Virginia Crop Improvement Association, 9225 Atlee Branch Lane, Mechanicsville, VA 23116.

MERL is a broadly adapted, high yielding, moderately short, mid-season soft red winter wheat cultivar having good milling and pastry baking quality. Spikes and straw of MERL are creamy white in color at maturity, and the awnletted spikes are blocky to tapering in shape. Head emergence of MERL (121 d, Julian) in Virginia is most similar to that of ‘Tribute’, and on average is 0 to 2 days earlier heading than Roane. Average plant height of MERL (33.5 inches) is 1.5 inches shorter than SS ‘MPV57’ and 2 inches taller than ‘Jamestown’. Straw strength (0=Erect to 9=Completely lodged) of MERL (1.4 – 2.0) is better than that of Roane (3.0 – 4.1). In Virginia, MERL had a three year (2006 – 2008) average grain yield (92 Bu/ac) that was similar to that of the highest yield cultivar Shirley, and an average test weight of 60.3 Lb/Bu that was significantly above the test averages in three out of four years. Winter hardiness and spring freeze tolerance (0=No injury to 9=Complete kill) of MERL is moderate (2.5 and 4.6), but less than that of Roane (1.7 and 2.9). MERL is resistant to powdery mildew (*Blumeria graminis*) and moderately resistant to stripe rust (*Puccinia striiformis*). MERL is susceptible to stem rust (*Puccinia graminis*), Soilborne Mosaic Virus, and Hessian fly [*Mayetiola destructor* (Say)]. In Virginia, Fusarium head blight [*Fusarium graminearum* (Schwabe)] disease index scores (0 – 100) for MERL have ranged from 4 to 17 with DON toxin concentrations from 0.7 to 1.3 ppm. In five Uniform Eastern Nursery tests, average FHB index scores of MERL (32 – 51) were higher than those of the resistant cultivar Roane (13 – 23).

On the basis of six independent milling and baking quality evaluations over three crop years (2005-2007), MERL has consistently exhibited good milling and pastry baking quality. MERL's good milling quality is attributed to its soft grain texture, low endosperm separation indices (9.1 – 9.7%), high break flour yields (30.0 – 30.6%), and high straight grade flour yields (76.9 – 71.1%) on an Allis mill. Flour protein concentrations of MERL are lower than average ranging from 7.38% to 9.01%, and protein gluten strength is moderately weak on the basis of Lactic Acid Retention Capacity values ranging from 95.8% to 103.9%. The aforementioned quality attributes of MERL and the low Sucrose Retention Capacity (88.9% – 93.2%) of its flour contribute to its good pastry baking quality as exemplified by high values for cookie spread diameter (mean of 18.06 cm).

Grain of MERL submitted for evaluation by Wheat Quality Council was produced in 2009 at the Foundation Seed Farm of the Virginia Crop Improvement Association located at Mount Holly, VA. Grain was produced using intensive management practices including split application of spring N, Prosaro fungicide and Warrior insecticide. The 2008-2009 production season had cooler and drier winter conditions than normal followed by warmer and wetter conditions during flowering which resulted in widespread and severe FHB epidemics. Wet weather delayed harvest in many areas resulting in further degradation of grain quality.

**SW049029104**
Soft red winter wheat

The soft red winter wheat cultivar SW049029104, previously designated VA04W-90, was developed and released by the Virginia Agricultural Experiment Station in March 2009. It was derived from the cross '38158' (PI 619052=SS 520) / Pioneer Brand '2552' // 'Roane'. Cultivar SW049029104 has been evaluated in Virginia's Official State Variety Trial (http://www.grains.cses.vt.edu/) since 2006, and was evaluated in the 2008-2009 USDA-ARS Uniform Southern Soft Red Winter Wheat Nursery (http://www.ars.usda.gov/main/docs.htm?docid=2925). Wheat cultivar SW049029104 is widely adapted and provides producers and end users in the mid to deep South, mid-Atlantic, and southern Corn Belt regions of the U.S. with a FHB resistant cultivar that has high yield potential and good milling and pastry baking qualities. Foundation seed of SW049029104 was first distributed to seedsmen in fall 2009. SW049029104 will be marketed by UniSouth Genetics (USG 3315), Seedway (SW52) and Growmark (FS888).

Wheat cultivar SW049029104 (VA04W-90) is a broadly adapted, high yielding, moderately short, mid-season soft red winter wheat. At physiological maturity, SW049029104 has purple straw color and its tapering awnletted spikes are creamy white in color. Head emergence of SW049029104 in Virginia (121 d, Julian) is most similar to that of 'Tribute', and on average is 1 day later heading than 'USG 3209'. Plant height of SW049029104 (34 inches) on average is 2 inches taller than USG 3209 and 1 inch shorter than SS Brand 520 ('38158') and 'AGS2000'. Straw strength (0=Erect to 9=completely lodged) of SW049029104 (0 to 2) is very good. In Virginia, SW049029104 had a three year average (2006-2008) grain yield (88 Bu/ac) that was similar to the overall entry mean, and its average test weight (59.8 Lb/Bu) was 1.2 Lb/Bu higher than that of SS Brand 520 ('38158'). In the 2009 USDA-ARS Uniform Southern SRW Wheat Nursery conducted over 25 locations, SW049029104 ranked 1$^{st}$ among 40 entries for grain yield (72.8 Bu/ac) and 4$^{th}$ for test weight (56.9 Lb/Bu). Winter hardiness of SW049029104 (winter kill score of 4.6 where 0=No injury to 9=Complete kill) is moderate in comparison to AGS2000 (5.2) and Pioneer Brand '26R61' (5.5).

Wheat cultivar SW049029104 is resistant to powdery mildew (*Blumeria graminis*) with mean ratings (0=immunity to 9=very susceptible) ranging from 0 to 1.5. Reaction of SW049029104 to leaf rust (*Puccinia triticina*) and stripe rust (*Puccinia striiformis*) has ranged from a mean of 1.5 to 5.8. It is moderately resistant to Barley Yellow Dwarf Virus (1.0 - 3.6), *Septoria tritici* leaf blotch (3.5 - 4.5), *Stagonospora nodorum* leaf (3.0) and glume (2.0 - 4.0) blotches, and Wheat Spindle Streak Mosaic Virus (3.3). It is resistant to Fusarium head blight [*Fusarium graminearum* (Schwabe)] having disease index scores (0 – 100) ranging from 5 to 8 and DON toxin concentrations from 0.1 to 0.6 ppm in Virginia. In the 2009 Uniform Southern Nursery, SW049029104 had a mean FHB rating (0=No infection to 9=Severe infection) of 3.7 and a Fusarium Damaged Kernel rating of 9.1%. Reaction of SW049029104 to Hessian fly [*Mayetiola destructor* (Say)] in field tests has varied from 2 to 3.

On the basis of three independent milling and baking quality evaluations over two crop years (2006-2007), milling and baking quality of SW049029104 have been similar to that of McCormick. On average SW049029104 and McCormick had similar values for softness equivalent (57.9% vs. 57.8%), flour yield (72.3% vs. 72.7%), and cookie spread diameter (17.71 vs. 17.72 cm). While flour protein of SW049029104 (8.40%) is slightly lower than that of McCormick (8.86%), gluten strength (Lactic acid retention capacity) of SW049029104 flour (111%) is higher than that of McCormick (103%). Thus, flour from SW049029104 likely can be used in the production of baked goods, such as crackers, requiring moderate to high gluten strength as well as production of pastry products such as cookies and cakes.

Grain of SW049029104 submitted for evaluation by Wheat Quality Council was produced in 2009 at the Foundation Seed Farm of the Virginia Crop Improvement Association located at Mount Holly, VA. Grain was produced using intensive management practices including split application of spring N, Prosaro fungicide and Warrior insecticide. The 2008-2009 production season had cooler and drier winter conditions than normal followed by warmer and wetter conditions during flowering which resulted in widespread and severe FHB epidemics. Wet weather delayed harvest in many areas resulting in further degradation of grain quality.

**Southern States Brand 5205**
Soft red winter wheat

The soft red winter wheat cultivar Southern States Brand 5205 (SS‘5205’) was derived from the three-way cross Pioneer Brand ‘2684’/VA93-54-185//’Pocahontas’. Parentage of VA93-54-185 is ‘Wheeler’/3/’Massey’*3/’Balkan’//’Saluda’. SS‘5205’ is a broadly adapted, high yielding, short stature, mid-season soft red winter wheat cultivar that provides producers and end users in the Deep South, mid-South, mid-Atlantic, and southern Corn Belt regions of the U.S. with a cultivar having very good milling and baking qualities. In the southern SRW wheat region, SS ‘5205’ on average is 0 to 1 days earlier heading than ‘McCormick’ and 1 to 4 days later than ‘USG 3209’. Plant height of SS‘5205’ (30 inch) on average is 1 to 2 inches shorter than those of USG 3209 and McCormick and 5 to 6 inches shorter than SS ‘MPV57’. Straw strength (0-9 scale) of SS‘5205’ (1.4) in the eastern SRW on average is better than those of USG 3209 (2.1) and McCormick (2.4).

SS‘5205’ was evaluated at 17 locations in the 2006-07 USDA-ARS Uniform Southern Soft Red Winter Wheat Nursery, and ranked 6th among 39 entries for grain yield (66.8 Bu/ac). SS‘5205’ produced yields that were similar to or significantly higher than the test averages at all 17 locations. SS‘5205’ also was evaluated in this uniform nursery in 2005-06 over 26 locations, and ranked 13th among 45 entries for grain yield (79.8 Bu/ac). SS‘5205’ produced yields similar to or significantly higher than the test average at 24 of the 26 test sites. Average test weight of SS‘5205’ in both years (59.1 Lb/Bu) was similar to that of McCormick and higher than that of USG 3209 (58.1 Lb/Bu). On the basis of winter kill ratings (0 = no injury to 9 = complete kill) reported at 4 of the 19 locations in 2007 and at 3 of the 26 test sites in 2006, winter hardiness of SS‘5205’ (5.1 and 1.0, respectively) is similar to that of USG 3209 and Pioneer 26R61, but less than that of McCormick (2.7 and 0.7).

SS‘5205’ is resistant to leaf rust (*Puccinia triticina*) and stripe rust (*Puccinia striiformis*). SS‘5205’ has expressed moderate resistance to powdery mildew (*Blumeria graminis*), stem rust (*Puccinia graminis*), Barley Yellow Dwarf Virus, Wheat Spindle Streak Mosaic Virus, Soil Borne Mosaic Virus, *Septoria tritici* leaf blotch, and *Stagonospora nodorum* glume blotch. It has expressed a moderate level of resistance to Fusarium head blight [*Fusarium graminearum* (Schwabe)] with disease index scores (0 – 100) ranging from 2.7 to 16 and DON toxin concentrations ranging from 0.3 to 1.3 ppm in Virginia Tech’s inoculated, mist-irrigated FHB nursery. SS’5205’ is moderately susceptible to black chaff (*Xanthomonas campestris*) and Hessian fly [*Mayetiola destructor* (Say)].
On the basis of eight independent milling and baking quality evaluations over five crop years (2003-2007), SS‘5205’ has consistently exhibited very good milling and pastry baking quality.

The very good to excellent milling quality of SS‘5205’ is attributed to its soft grain texture, low endosperm separation indices (9.1%), high break flour yields (32.6 – 36.6%), and high straight grade flour yields (77.2 – 78.9%) on an Allis mill. Flour protein concentration of SS‘5205’ (8.61%) is lower than that of McCormick (9.23%), yet on the basis of Lactic Acid Retention Capacity, gluten strength of SS‘5205’ (113.3%) is higher than that of McCormick (109.7%). Thus, flour from SS‘5205’ likely can be used in the production of crackers, requiring moderate to high gluten strength, as well as production of excellent pastry products such as cookies and cakes.

**Shirley**
Soft red winter wheat

The soft red winter wheat cultivar Shirley (VA03W-409) was derived from the three-way cross VA94-52-25 / ‘Coker 9835’// VA96-54-234. The parentage of VA94-52-25 is CI 13836/9* ’Chancellor’//2* ‘Tyler’/3/2* ‘Massey’/4/‘Hunter’/5/‘Saluda’. The parental line VA96-54-234 is a sib of ‘Sisson’ and ‘Choptank’. Shirley is a broadly adapted, high yielding, short stature, full season soft red winter wheat cultivar that provides producers and end users in the mid-South, mid-Atlantic, Corn Belt, and Northeastern regions of the U.S. with a cultivar that has very good milling and pastry baking qualities. Head emergence of Shirley in the eastern SRW wheat region on average is 0 to 3 days later heading than ‘Roane’. Average plant height of Shirley (32 inches) is 3 inches shorter than SS ‘MPV57’ and 1 to 2 inches taller than ‘Jamestown’. Straw strength (0 – 9 scale) of Shirley (1.5 – 2.0) in the eastern SRW region is better than that of Roane (3.2 – 4.1).

Shirley Y was evaluated at 22 locations in the 2006-07 USDA-ARS Uniform Eastern Soft Red Winter Wheat Nursery, and ranked 1st among 44 entries for grain yield (81.2 Bu/ac). Shirley ranked among the top ten entries at 17 of the 22 locations and produced yields that were similar to or significantly higher than the test averages at all 22 locations. Average test weight of Shirley (57.6 Lb/Bu) was similar to those of check cultivars Patton (57.7 Lb/Bu) and INW 0411 (57.3 Lb/Bu). Shirley also was evaluated in this uniform nursery in 2005-06 over 29 locations, and ranked 1st among 46 entries for grain yield (91.6 Bu/ac). Shirley ranked among the top 10 entries at 17 of the 29 locations and produced yields that were similar to or significantly higher than the test average at all replicated test sites. Average test weight of Shirley (56.8 Lb/Bu) was similar to that of check cultivar INW 0411 (56.6 Lb/Bu). On the basis of winter kill ratings (0 = no injury to 9 = complete kill) reported at 9 of the 22 locations in 2007, Shirley had an average score of 2.0 compared to 1.7 for Roane.

Shirley is resistant to leaf rust (*Puccinia triticina*), stem rust (*Puccinia graminis*), powdery mildew (*Blumeria graminis*), Barley Yellow Dwarf Virus, Wheat Spindle Streak Mosaic Virus, *Septoria tritici* leaf blotch, *Stagonospora nodorum* leaf and glume blotches. Shirley is moderately resistant to black chaff (*Xanthomonas campestris*). It has expressed a moderate level of resistance to Fusarium head blight [*Fusarium graminearum* (Schwabe)] with disease index scores (0 – 100) ranging from 6.5 to 18 and DON toxin concentrations ranging from 0.2 to 3.1 ppm in Virginia Tech’s inoculated, mist-irrigated FHB nursery. Shirley expresses resistance to Hessian fly [*Mayetiola* *destructor* (Say)] biotype C, but is susceptible to biotypes B, D, and L. Shirley is susceptible to stripe rust (*Puccinia striiformis*).

On the basis of four independent milling and baking quality evaluations over three crop years (2005-2007), Shirley has consistently exhibited very good milling and pastry baking quality. Shirley's very good milling quality is attributed to its soft grain texture, low endosperm separation indices (8.9%), high break flour yields (32.3 – 32.8%), and high straight grade flour yields (77.7 – 77.9%) on an Allis mill. Flour protein concentrations of SHIRLEY are lower than average ranging from 7.62% to 8.65%, and protein gluten strength is weak on the basis of low Lactic Acid Retention Capacity values ranging from 84.6% to 93.6%. The aforementioned quality attributes of SHIRLEY and the low Sucrose Retention Capacity (87.6% – 90.8%) of its flour contribute to its very good pastry baking quality as exemplified by high values for cookie spread diameter (17.15 – 18.65 cm).

**Renwood Brand 3434** Soft red winter wheat
The soft red winter wheat cultivar Renwood Brand 3434 (Renwood '3434') was derived from the three-way cross 'Roane'/'Coker 9835'//VA96W-270. Parentage of VA96W-270 is VA88-54-612 ('Massey'*2/'Balkan') /'FFR511W'. Renwood '3434' is a broadly adapted, high yielding, short stature, full-season soft red winter wheat cultivar that provides producers and end users in the mid-South, mid-Atlantic, Northeast, and Corn-Belt regions of the U.S. with a stiff-straw cultivar having good baking quality. Head emergence of Renwood '3434' (124 d, Julian) is 1 day later than 'McCormick' and 1 day earlier than Roane. Plant height of Renwood '3434' is very short (28 inches) and on average is 2 inches shorter than 'USG 3209' and 6 inches shorter than SS 'MPV57'. Straw strength (0 – 9) of Renwood '3434' is better than that of USG 3209 (1.7 vs. 2.5) in the southern region and that of Roane (1.9 vs. 4.1) in the eastern SRW winter wheat region.

Renwood '3434' was evaluated at 17 locations in the 2006-07 USDA-ARS Uniform Southern Soft Red Winter Wheat Nursery, and ranked 7th among 39 entries for grain yield (66.3 Bu/ac). Renwood '3434' produced yields that were similar to or significantly higher than the test averages at all 17 locations. Average test weight of Renwood '3434' (57.5 Lb/Bu) was most similar to that of USG 3209 (58.1 Lb/Bu). Renwood '3434' also was evaluated at 22 locations in the 2006-07 USDA-ARS Uniform Eastern Soft Red Winter Wheat Nursery, and ranked 20th among 44 entries for grain yield (72.1 Bu/ac). Renwood '3434' produced yields similar to or significantly higher than the test averages at 21 of the 22 test sites. Average test weight of Renwood '3434' (57.9 Lb/Bu) was similar to those of check cultivars Patton (57.7 Lb/Bu) and Foster (58.1 Lb/Bu). On the basis of winter kill ratings (0 = no injury to 9 = complete kill) reported at 4 of the 19 southern nursery locations and at 9 of the 22 eastern nursery test sites, winter hardiness of Renwood '3434' (2.8 and 2.1, respectively) is similar to that of McCormick (2.7) and slightly less than that of Roane (1.7).

Renwood '3434' is resistant to powdery mildew (*Blumeria graminis*). It is moderately resistant to leaf rust (*Puccinia triticina*), stem rust (*Puccinia graminis*), Barley Yellow

Dwarf Virus, Soil Borne Mosaic Virus, *Septoria tritici* leaf blotch, and *Stagonospora nodorum* glume blotch. Renwood ‘3434’ has expressed a moderate level of resistance to Fusarium head blight [*Fusarium graminearum* (Schwabe)] with disease index scores (0 – 100) ranging from 2.1 to 21.5 and DON toxin concentrations ranging from 0 to 1.5 ppm in Virginia Tech’s inoculated, mist-irrigated FHB nursery. Renwood ‘3434’ is moderately susceptible to stripe rust (*Puccinia striiformis*) and black chaff (*Xanthomonas campestris*). It is susceptible to Hessian fly [*Mayetiola destructor* (Say)].

On the basis of five independent milling and baking quality evaluations over three crop years (2005-2007), Renwood ‘3434’ has exhibited acceptable milling and good pastry baking qualities. While endosperm separation indices (10.5 to 10.9%) of Renwood ‘3434’ tend to be high, it has soft grain texture (70.8% – 88.0%) and moderately high break flour yields (31.4% – 32.7%). Straight grade flour yields of Renwood ‘3434’ from an Allis Chalmers Mill have been 75.7% to 76.2%. Flour protein concentration of Renwood ‘3434’ is moderately low and has varied from 7.57% to 9.46%. Gluten strength of Renwood ‘3434’ is moderately weak with Lactic Acid Retention Capacity values varying from 98.8% to 110.1%. The aforementioned quality attributes of Renwood ‘3434’ and the low Sucrose Retention Capacity (85.8% – 88.5%) of its flour contribute to its good pastry baking quality as exemplified by relatively high values for cookie spread diameter (17.08 – 18.81 cm).

**Jamestown (VA02W-370)** Soft red winter wheat
The soft red winter wheat cultivar JAMESTOWN was derived from the cross ‘Roane’/ Pioneer Brand ‘2691’. The cultivar was approved for release by the Virginia Agricultural Experiment Station in spring 2007, and certified seed was available in Fall 2009. JAMESTOWN is a distinctly early heading, high yielding, short stature, awned, soft red winter wheat cultivar. JAMESTOWN is widely adapted and provides producers in the mid-South, Deep South, and throughout the mid-Atlantic region with a distinctly early maturing, disease and pest resistant cultivar. JAMESTOWN is notable resistant to Hessian fly, leaf rust, stripe rust, powdery mildew, and Fusarium head blight.

On the basis of milling and baking quality evaluations over four crop years (2003-2006), JAMESTOWN tends to have higher break flour yields (30.5% versus 28.3%) and slightly softer texture (higher softness equivalent score 57.4% versus 54.1%) than USG 3209. Straight grade flour yields of JAMESTOWN (71.7%) have been slightly higher than those of USG 3209 (71.1%).

On average JAMESTOWN has higher flour protein concentration (8.92% versus 8.66%) and gluten strength (lactic acid retention value of 113% versus 107%) than USG 3209 and, therefore, may be suitable for use in making crackers and other products requiring moderate gluten strength. Overall, JAMESTOWN has better baking quality than USG 3209 on the basis of lower values for sucrose retention capacity (93.8% versus 104%) and larger cookie diameters (17.0 cm versus 16.8 cm).

# Materials and Methods

## Quality Characteristics of Soft Wheat Cultivars with Allis Milling

Milling quality is a highly heritable genetic trait. Milling-quality score consists of straight-grade flour yield, endosperm separation index (ESI) and friability. Other milling quality parameters also can be utilized from the Allis-Chalmers milling data. Data represent millings from a modified Allis-Chalmers mill of "shrivel-free" grain from various locations and/or crop years (1975-2008). Every effort has been adopted to insure that milling-quality data are representative of the cultivar. However, there is a measure of uncertainty in data representing a cultivar singularly milled. Known standard cultivars that are contained within a set are milled and then compared to the previous milling information for those cultivars. The break-flour yield, test weight and 1000-kernal weight for an individual sample are not especially useful parameters, but comparing the break-flour yields, test weights and 1000-kernel weights of the various known standards can be utilized to establish confidence in verification of the named standards provided in a set.

## Grain Handling

**Grain Production**
Historic varieties dating to 1808 (and likely earlier) were acquired through the National Small Grains Collection (located in Aberdeen, Idaho, and formerly in Beltsville, Maryland). These are grown with contemporary cultivars. Plant characteristics of the historic varieties and contemporary cultivars are compared with recorded plant descriptions; the identity of the various varieties is confirmed. Yearly, the SWQL grows 200 to 300 cultivars/varieties in forty-square-foot plots.

**Grain Cleaning and Sizing**
Prior to 1985, most of the shriveled grain was removed mechanically utilizing a modified Carter-Day dockage tester or an air-flow scourer. However, some shriveled grain could have been present in the remaining sample. In 1985, the Carter-Day was further modified to remove shriveled kernels by air aspiration. The ability to remove shrunken grain was greatly enhanced, but the process was time consuming.

In 1989, a large air-aspirator was fabricated by the SWQL that reduced cleaning time significantly and removed shriveled kernels. In 2002, the SWQL began to re-evaluate cultivars that were tested prior to 1989 and to update the milling information if needed. That effort was mostly completed in the summer of 2006.

Every cultivar designated for Allis milling is mechanically sized into three or four fractions on a SWQL-modified Carter-Day Dockage Tester and then aspirated. A maximum of 2500 grams can be aspirated at one time. Air flow is electronically adjustable and the lower density shriveled grain within each sized fraction is removed. Visual inspection through a lighted magnifier is used to ascertain that only sound grain remains. Once aspiration of the wheat has been completed, the cleaned sized fractions are blended. Test weight, 1000-kernel weight and moisture are determined prior to milling.

**Weather and Environment**
Weather damaged cultivars that produce diminished milling quality can be difficult to identify if known standards are not incorporated within the field trial. In the northern soft wheat region, wet weather at or near harvest time occurred most years from 1990 to 2000 and again in 2003. Some cultivars prominent during that decade produced milling quality data unreflective of their true genetic potential. After a specific cultivar is identified that produced “invalid” milling data, that milling information is replaced with the updated analysis. A cultivar’s revised milling score could increase by as much as two standard deviations.

An “off color” flour can appear in wheats which are genetically “white” when there is an excessive quantity of wet weather at harvest time. A yellowish flour color sometimes occurs in cultivars that are normally white when the environment “produces” a coarser granulating flour than normal.

Wet weather at harvest time will lower test weights and grain density, and can greatly increase the softness of the kernel so that the flour produces larger cookie spread, although milling-yield potential is not affected. Throughput at the 1st-break rolls is diminished with weathered wheat. However, since the wheat is softer, break-flour yield increases and less middling stock is passed to the reduction rolls. That would result in reduced energy required to power the rolls with less wear on the roll surface. More throughput could possibly be realized with softer-weathered wheat versus coarser type wheat if a double 1st-break system were employed.

Excessively wet weather at harvest time can damage wheat for milling quality. Sprouted wheat (after aspiration) can possess higher test weights than unsprouted wheats. After aspiration to remove shriveled grain, a sprouted wheat may have a test weight in excess of 60# / bushel compared to weathered, unsprouted, non-shriveled wheat with 57# / bushel test weight. Alpha-amylase activity may be present despite a lack of visual evidence of sprouting.

Moderate infection from leaf diseases apparently does not affect milling properties once damaged (shriveled) kernels have been removed; however, baking quality of sugar snap cookies may be affected.

# Milling Methods

## Allis Mill

The Allis-Chalmers mill was acquired in 1909 by the Ohio Agricultural Experiment Station. Chester Evans, a practical miller, was put in charge of the milling operation and baking plant. Mr. Evans came to the station from Williams Brothers Milling, Kent, Ohio. Apparently the Allis-Chalmers mill was donated to the Soft Wheat Quality Laboratory around 1937. The mill was extensively modified during the early 1970's: self-aligning, double-row roller bearings, and extensions manufactured for the roll spacing control arms. A one-inch movement of the control arm around a twenty-four inch radius is equal to one thousandth of an inch (25 microns) change in roll separation. The standard deviation for flour yield of duplicate millings is 0.15%.

**Kernel weight** is determined on each cleaned sample and grain volume weight measured. Following grain measurements, samples are tempered to 15% moisture. Tempered grain is milled on the SWQL Allis-Chalmers flour mill using the AACC method 26-32 as modified by Yamazaki and Andrews (1982)[6]. The Allis-Chalmers mill is a long-flow experimental milling system with adjustable roll gaps. Grain is initially milled with six break roll passes then reduced in seven reduction roll passes to produce straight grade flour. The roll settings, sifting screen sizes, and mill flow were as diagramed in Yamazaki and Andrews (1982).

For each grain sample, straight grade flour yield and break flour yield are recorded.

**Data Analysis and Interpretation of Allis Milling**
Since milling quality is a highly heritable genetic trait, excluding weather damaged examples, a single sample likely will produce representative milling yield, ESI and friability. Also, lactic acid solvent retention capacity values within a milling system are highly heritable in all published genetic studies of wheat. However, test weight, kernel weight, break flour yield, cookie baking, flour protein and ash can be influenced significantly by environmental variations. Usually, mean data from three millings will yield quality assessments that are more representative of those traits that are less stable. The number of samples included in the computation of the average is specified for each cultivar. A cultivar that has been composited from several locations/crop years may produce quality data that more nearly reflects its genetic nature. Cultivars listed in the tables that have a "c" beside the "number for the average" indicate that a composite sample has been milled to generate the quality data.

[6] Yamazaki, W.T. and L.C. Andrews. 1982. Experimental milling of soft wheat cultivars and breeding lines. Cereal Chem. 59:41-45.

## Miag Multomat Mill

The Miag Multomat Mill is a pneumatic conveyance system consisting of eight pair of 254 mm diameter x 102 mm wide rolls, and ten sifting passages. Three pair are corrugated and employed as break rolls and five pair are smooth rolls utilized in the reduction process. Each sifting passage contains six separate sieves. The two top sieves for each of the break rolls are intended to be used as scalp screens for the bran. The third break sieving unit of the Soft Wheat Quality Laboratory (SWQL) Miag Multomat Mill was modified so that the top four sieves are employed to scalp bran. That modification increased the final bran sieving surface by 100% and essentially eliminated any loss of flour. Thus, the mill very closely approximates full scale commercial milling.

### Experimental Milling Procedure

All SRW varieties are tempered to a 14.0% moisture level. Generally tempered wheat is held for at least 24 hours in order for the moisture to equilibrate throughout the grain. Wheat is introduced into the first break rolls at a rate of 54.4 Kg/hour (120# / hour). Straight grade flour is a blend of ten flour streams, the three break flour streams and the five reduction streams, plus the grader flour from the break streams and the duster flour from the reduction streams. The straight grade flour mean volume diameter is about 50 microns with an ash content usually between 0.42% and 0.52%.

Flour generated by the (SWQL) Miag Multomat Mill very nearly represents that of commercially produced straight grade flour. Bran, head shorts, tail shorts and red dog are by-products which are not included with the flour. Flour yields vary between 70% and 78%, which is variety-dependent due to milling quality differences and/or grain condition. Sprouted and/or shriveled kernels negatively impact flour production. Recovery of all mill products is usually about 99%. Least significant differences for straight grade flour yield and break flour yield are 0.75% and 0.82%, respectively.

## Quadrumat Junior Flour Mill

### Micro Milling Method

Based on average whole grain moisture determination of a subset of the group to be milled, samples are tempered to 15% moisture. Sample preparation for moisture determination uses the low speed Tag-Heppenstall corrugated rolls that have a roll speed differential of 1:1. Tempered grain samples are milled after 48 hours to allow for equal water distribution throughout the kernel.

Samples are milled in a control temperature and humidity room (19 – 21 $^{o}$C and RH 55% - 60%). Milling is conducted on a modified Quadrumat Junior flour mill. Prior to sample analysis, mill should be operating, warm, and equilibrated (36 $^{o}$C + /- 1.0). Standard sample size for micro milling is 80 g, although other samples sizes can be used. Tempered grain is milled and the product recovered for sifting on a Great Western sifter box. The sifter should have 40 mesh and 94 mesh screens to separate mill product into bran (above 40), mids (between 40 and 94) and flour (through the 94 screen and recovered in the flour pan on the bottom).

To calculate softness equivalent (a modified particle size index), the weights of the bran and mids are recorded. The mids are added back to the flour that passed through the 94 mesh screen to produce the final flour product for analysis.

### Advanced Milling Method

Mids from micro milling method are further processed as reduction milling on a second Quadrumat Junior mill and sieved as for the micro milling method using an 84 mesh screen to produce baking quality flour. Standard sample size for advanced milling is 200 g, and grain samples are tempered individually to 15% moisture prior to milling. Milled flour is passed through an 84 mesh screen and combined with flour from the micro milling for baking.

Because samples are tempered individually to 15%, the formulas for advanced milling yield are calculated without the adjustment to15% moisture.

# Milling Tests

**Endosperm Separation Index (ESI)** was calculated as described by Yamazaki and Andrews (1982). ESI is the estimated endosperm adhering to bran and bran pieces after the third through fifth break passes and first reduction pass, expressed as a percentage based on the weight of milled grain divided into the flour recovered in the break rolls after the second break stream and the reduction rolls after the first break. Lower ESI values indicate better bran separation from endosperm and better milling quality than higher ESI values.

The quantities of final bran plus four other bran-rich fractions obtained at an intermediate stage of milling are recorded and essentially represent all of the bran. The bran (14.5%) and the germ (2.5%) are subtracted to yield endosperm remaining attached to the bran. The lower that value is, the better the separation was between endosperm and bran. Thus, a lower ESI value indicates better wheat for milling since less energy is required to produce straight-grade flour.

**Friability**
Gaines et al., 2000[7], estimated the ease with which mill stock is reduced to flour. Friability is calculated by dividing the weight of flour recovered during milling by the summed weight of mill stock passed through all roll stands, break and reduction, after the first break. The earlier in the break and reduction process that flour is recovered, the lower the weight of mill stock that passes to the later break and reduction rolls. Higher values of friability indicate better milling efficiency and reduced energy requirements to recover flour.

Friability is the tendency of the wheat endosperm conglomerates to reduce to flour as a result of corrugated and smooth roll action. The cumulative quantity of stock entering the rolls (usually 20 streams) and the percent of flour extracted from the stock relate to the total energy consumed by the milling process. A higher percentage of friability means that less energy is required per unit of flour extraction.

Friabilities above 30.5% are rare and only exceptionally good milling wheats fall into this category. Those cultivars displaying friabilities below 27% usually reflect very poor reduction of middling stock on the smooth rolls.

Poor milling-quality cultivars produce middling stocks which do not release flour well after being crushed on the smooth rolls, resulting in higher quantities of carry-over to subsequent reduction rolls. Cultivars that have reduced milling properties due to “weathering” do not reduce well on the smooth rolls and the endosperm and bran do not separate well on the corrugated rolls.

[7] Gaines, C.S., P.L. Finney, and L.C. Andrews. 2000. Developing agreement between very short flow and longer flow test wheat mills. Cereal Sci. 77:187-192.

Milling a cultivar with a friability of 25% compared to one of 30% would produce about a 15% increase in the amount of stock entering the corrugated and smooth rolls of the SWQL Allis-Chalmers mill. When milling 60,000 # (1000 bu) of wheat per hour, the quantity passing thru the SWQL mill (not including 1st break) would be 179,000 # of stock for the cultivar with lower friability compared to 156,000 # for the cultivar with higher friability. The cultivar with friability of 25% would also yield about 3.5% less flour.

**Flour yield**
Flour yield "as is" is calculated as the bran weight (over 40 weight) subtracted from the grain weight, divided by grain weight and times 100 to equal "as is" flour yield. Flour yield is calculated to a 15% grain moisture basis as follows: flour moisture is regressed to predict the grain moisture of the wheat when it went into the Quad Mill using the formula Initial grain moisture = 1.3429 x (flour moisture) – 4. The flour yields are corrected back to 15% grain moisture after estimating the initial grain moisture using the formula Flour $\text{Yield}_{(15\%)}$ = Flour $\text{Yield}_{(\text{as is})}$ - 1.61% x (15% - Actual flour moisture).

**Softness Equivalent**
Softness Equivalent "as is" is calculated from the fraction of mill product that is in the mids, with smaller amounts of mids correlating to smaller particle size, greater break flour yield, and greater softness equivalent. The mids weight (over 94) is subtracted from the unadjusted flour yield to calculate the quantity of fine flour that passed through the 94 mesh, which is divided by the unadjusted flour yield and multiplied by 100%. Softness Equivalent at 15% grain moisture is calculated using the estimated grain moisture prior to milling (see milling formulas). The softness equivalents are adjusted to 15% grain moisture with the formula Softness $\text{Equivalent}_{(15\%)}$ =
Softness $\text{Equivalent}_{(\text{as is})}$ - 1.08% x (15% - Actual flour moisture).

**Flour yield adjustment**[8] based on flour particle size 52% is subtracted from the actual softness equivalent. That difference is multiplied times 0.17% which is the change in flour yield per percentage point change in softness equivalent. Therefore, Adjusted Flour Yield = Flour $\text{Yield}_{(15\%)}$ + (Softness $\text{Equivalent}_{(15\%)}$ - 52%)[9].

**Mill Score**
Mill score represents a standard adjustment based on flour yield by comparing the test cultivar to a check. The check cultivar produces a score that can be used as a handicap against its traditional expected yield, and the test cultivar mill score is adjusted to the same degree as the check. This method relates test cultivars providing a score that is independent of the environmental influences. The mill score standard deviation will be about 1.43 when evaluating cultivars and test lines that have been grown and harvested together.

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[8] On the small Quad Mill, coarser type soft wheats will appear to mill better than they should and conversely, softer type soft wheats will have suppressed "as is" flour yields.
[9] Micro milling adjustments were developed by Lonnie Andrews with Patrick Finney and Charles Gaines. Additional details are included in the Standard Operating Procedures for the Soft Wheat Quality Laboratory.

# Kernel and Whole Wheat Tests

**New Method - Whole Wheat Flour Moisture**
(Air-oven method, modified AACC 44-16)

Apparatus
1. Tag-Heppenstall rolls
2. Moisture dish (about 5.5cm diameter x 1.5cm height, with slipover lid)
3. Air oven – a convection oven which maintains temperature 140 ± $1^o$.
4. Aluminum plate

Procedure
1. Scoop out approximately one teaspoon of wheat into a moisture dish. As many as 36 samples may be run at once.
2. Pass the wheat sample through the Tag-Heppenstall rolls with a pan placed below to collect the ground sample. The black knob on the side of the unit may be used to assist the wheat through the rolls if necessary. Transfer the ground sample to the moisture dish and cover the dish with a lid.
3. Record the weight of the dish plus lid containing the ground sample (*initial weight*). Samples should be weighed soon after grinding and not allowed to sit for more than a few minutes in order to minimize moisture loss prior to weighing.
4. Open the lid, and place the dish and lid in the oven at 140°C. Once all dishes and lids have been placed in the oven, allow the temperature to return to 140°C and set a timer for 90 minutes.
5. At the end of the 90 minute drying time, cover the dishes with the lids and transfer them to an aluminum plate outside oven to cool for 5 minutes. It is recommended that no more than 12 dishes be taken out of the oven at once in order for the cooling time to remain consistent.
6. Record the weight of the dish plus lid containing the dried flour (*final weight*). Continue weighing all dishes that have been taken out of the oven.
7. Empty the samples from the dishes, brush any residue from the dishes and lids, and record the weights (*dish weight*).
8. Percent moisture may be calculated using the following equation:

$$\%\, Moisture = \left[\frac{Initial\ wt - Final\ wt}{Initial\ wt - Dish\ wt}\right] * 100$$

**Whole Wheat Flour Moisture**
(AACC Method 44-15A) Air-oven method.

**Whole Wheat Flour Crude Protein**
Nitrogen combustion analysis using Elementar Nitrogen Analyzer. Units are recorded in % protein converted from nitrogen x 5.7 and expressed on 12% moisture basis.

**Whole Wheat Flour Falling Numbers**
(AACC Method 56-81B) Units are expressed in seconds using the Perten Falling Numbers instrument.

**Whole Wheat - Amylase Activity**
(AACC Method 22-06) Units are expressed in alpha-amylase activity as SKB units/gram (@ 25°C).

**Test Weight**
(AACC Method 55-10) Weight per Winchester bushel of cleaned wheat subsequent to the removal of dockage using a Carter-Day dockage tester. Units are recorded as pounds/bushel (lb/bu) and kilograms/hectoliter (kg/hl).

**1000-Kernel Weight**
Units are recorded as grams/ 1000 kernels of cleaned wheat. There is little difference between 1000-kernel weight and milling quality when considering shriveled-free grain. However, small kernelled cultivars that have 1000-kernel weight below 30 grams likely will have reduced milling yield of about 0.75%.

**Single Kernel Characterization System (SKCS)**
(AACC Method 55-31) SKCS distribution showing % soft (A), semi-soft (B), semi-hard (C), and hard (D); SKCS hardness index; SKCS moisture content; SKCS kernel size; and SKCS kernel weight; along with standard deviations.

# Flour Tests

**New Method - Flour Moisture**
(Air-oven method, modified AACC 44-16):

Apparatus

5. Moisture dish (about 5.5cm diameter x 1.5cm height, with slipover lid)
6. Air oven – a convection oven which maintains temperature 140 ± 1$^{o}$C.
7. Aluminum plate

Procedure

9. Scoop out approximately 1/2 teaspoon of flour into a moisture dish and cover the dish with a lid. As many as 36 samples may be run at once.
10. Record the weight of the dish plus lid containing the flour sample (*initial weight*).
11. Open the lid and place the dish and lid in the oven at 140°C. Once all dishes and lids have been placed in the oven, allow the temperature to return to 140°C and set a timer for 15 minutes.
12. At the end of the 15 minute drying time, cover the dishes with the lids and transfer them to an aluminum plate outside the oven to cool for 5 minutes. It is recommended that no more than 12 dishes be taken out of the oven at once in order for the cooling time to remain consistent.
13. Record the weight of the dish plus lid containing the dried flour (*final weight*). Continue weighing all dishes that have been taken out of the oven.
14. Empty the samples from the dishes, brush any residue from the dishes and lids, and record the weights (*dish weight*).
15. Percent moisture may be calculated using the following equation:

$$\%\, Moisture = \left[\frac{Initial\ wt - Final\ wt}{Initial\ wt - Dish\ wt}\right] * 100$$

**Flour Moisture**
(AACC Method 44-15A) Units are expressed as % of flour.

**Flour Falling Number**
(AACC Method 56-81B) Units are expressed in seconds using the Perten Falling Numbers instrument. Numbers above 400 seconds reflect factors other than alpha-amylase activity (such as particle size). The correlation between alpha-amylase activity and falling number is best for samples with falling number values between 200 and 300 seconds. For cake flours and batters, 350 seconds is a common minimum value. For breakfast cereals or cookies and other high sugar products, values of 250 seconds are more common cut-off values.

**Flour Crude Protein**
Protein determined by NIR using a Unity NIR instrument calibrated by nitrogen combustion analysis using Elementar Nitrogen Analyzer. Units are recorded in % protein converted from nitrogen x 5.7 and expressed on 14% moisture basis.

Flour protein differences among cultivars can be a reliable indicator of genetic variation provided the varieties are grown together, but can vary from year to year at any given location**.** Flour protein from a single, non-composite sample may not be representative. Based on the Soft Wheat Quality Laboratory grow-outs, protein can vary as much 1.5 % for a cultivar grown at various locations in the same ½ acre field.

Flour protein of 8% to 9% is representative for breeder's samples and SWQL grow-out cultivars. As flour protein increases, the expansive capability of the cookie during the baking process decreases. Flour protein is negatively correlated to cookie diameter ($r=-0.62$, $p<0.0001$) with the cookie shrinking 0.4 cm for every 1 percentage point increase in protein[10]. The effect of flour protein on cookie size is related in part to increased water absorption due to greater protein content, however the amount of cookie shrinkage is greater than that explained by increased water absorption alone.

**Protein quality** is an evaluation of "elasticity" or gluten strength and is not the same as protein quantity. A cultivar possessing a low quantity of protein could still exhibit strong gluten strength. Gluten strength is thought to be a desirable characteristic for cracker production. Gluten strength is measured using a mixograph and is graded on a scale of 1-8, with 1 as weakest and 8 as strongest gluten. Evaluation of gluten strength using the mixograph or farinograph is difficult for soft wheat flours that are 8.5% protein and lower. Since the representative protein range for breeders' samples is 8-9%, many of these flours are not adequately evaluated using the mixograph or farinograph methods. The Lactic Acid SRC, which does not require mixing action to assess gluten, tends to be a better measurement of protein quality when evaluating soft wheats. Lactic acid hydrates the native matrix of insoluble polymeric protein (IPP) present in the flour.

**Flour Ash**
(AACC Method 08-01) Basic method, expressed on 14% moisture basis.

**Flour Amylase activity**
(AACC Method 22-06) Units are expressed in α- amylase activity as SKB units/gram (@ 25°C).

[10] Correlations and prediction models cited in this section are based on 2289 samples milled at the Soft Wheat Quality Laboratory in 2007 an 2008 on the Quadrumat Advanced milling system.

**Flour micro Alpha Amylase activity**
(Adapted by Mary Gutierri) The new method adapts AACC Method 22-02 using the Ceralpha K-CERA (Megazyme) alpha amylase assay procedure for measuring alpha amylase activity at higher throughput in a microwell plate. All reagents, controls and precautions are as described in the Megazyme manual. Units are expressed as described as Ceralpha Units per gram (CU/g). The new assay is described completely at the end of this section as the Micro Assay for Flour Alpha Amylase Activity.

**Solvent Retention Capacity Test (SRC)**
(Flour Lactic Acid, Sucrose, Water, and Sodium Carbonate Retention Capacities AACC Method 56-11) Units are expressed as %.

**Water SRC** is a global measure of the water affinity of the macro-polymers (starch, arabinoxylans, gluten, and gliadins). It is often the best predictor of baked product performance. Water SRC is correlated to Farinograph water absorption but does not directly measure the absorption of the glutenin macropolymer hydration during mixing as does the Farinograph. Water SRC is negatively correlated to flour yield and softness equivalent among flour samples milled on the Quad advanced flour mill (r=-0.43 and r=-0.45, respectively). Lower water values are desired for cookies, cakes, and crackers, with target values below 51% on small experimental mills and 54% on commercial or long-flow experimental mills.

**Sucrose SRC** is a measure of arabinoxylans (also known as pentosans) content, which can strongly affect water absorption in baked products. Water soluble arabinoxylans are thought to be the fraction that most greatly increases sucrose SRC. Sucrose SRC probably is the best predictor of cookie quality, with sugar snap cookie diameters decreasing by 0.07 cm for each percentage point increase in sucrose SRC. The negative correlation between wire-cut cookie and sucrose SRC values is r=-0.66 ($p<0.0001$). Sucrose SRC typically increases in wheat samples with lower flour yield (r=-0.31) and lower softness equivalent (r=-0.23). The cross hydration of gliadins by sucrose also causes sucrose SRC values to be correlated to flour protein (r=0.52) and lactic acid SRC (r=0.62). Soft wheat flours for cookies typically have a target of 95% or less when used by the US baking industry for biscuits and crackers. Sucrose SRC values increase by 1% for every 5% increase in lactic acid SRC. The 95% target value can be exceeded in flour samples where a higher lactic acid SRC is required for product manufacture since the higher sucrose SRC is due to gluten hydration and not to swelling of the water soluble arabinoxylans.

**Sodium carbonate SRC** is a very alkaline solution that ionizes the ends of starch polymers increasing the water binding capacity of the molecule. Sodium carbonate SRC increases as starch damage due to milling increases. Sodium carbonate is an effective predictor of milling yield and is negatively correlated to flour yield on the Quad advanced milling system (r=-0.48, $p<0.0001$). It also is one of several predictors of cookie diameter (r=-0.22, $p<0.0001$). Normal values for good milling soft varieties are 68% or less.

**Lactic acid SRC** measures gluten strength. Typical values are below 85% for "weak" soft varieties and above 105% or 110% for "strong" gluten soft varieties. See the above discussion of protein quality in this section for additional details of the lactic acid SRC. Lactic acid SRC results correlate to the SDS-sedimentation test. The lactic acid SRC is also correlated to flour protein concentration, but the effect is dependent on genotypes and growing conditions. The SWQL typically reports a protein-corrected lactic acid SRC value to remove some of the inherent protein fluctuation not due to cultivar genetics. Lactic acid is corrected to 9% protein using the assumption of a 7% increase in lactic acid SRC for every 1% increase in flour protein. On average across 2007 and 2008, the change in lactic acid SRC value was closer to 2% for every 1% protein.

**Flour Damaged Starch** is measured by the Chopin SDMatic starch damage instrument using the supplied AACC calibration. Starch damage is a measure of the damage to the starch granule occurring during the milling process.

# Experimental Baked Product Tests

**Wire Cut Cookie:** (AACC Method 10-53, Macro Method)
This method determines the texture (hardness) of the cookies. The use of high-fructose corn syrup and lower sucrose concentration allows for a texture more similar to standard commercial cookie formulations. Differences in hardness reflect differences in flour quality, with softer cookie texture produced with better soft wheat quality.

**Baking Quality of Cookie Flour:** (AACC method 10-52, Micro Method)
Diameter and stack height of cookies baked according to this method are measured and used to evaluate flour baking quality. All data reported in this report were produced using the accepted method prior to December, 2008.

Cookie spread determined within a location is a reliable indicator of the source cultivar's genetic characteristics. However, cookie spread, unlike milling quality, is greatly influenced by environmental conditions. An absolute single value for cookie spread could be misleading. Within a location the single value is significantly important in comparison to known standards. The average cookie spread for three different examples of a cultivar is representative of that wheat.

Cultivars with larger cookie spreads tend to release moisture efficiently during the baking process due to lower water absorption while cultivars yielding smaller diameter cookies tend to be higher in water absorption and hold the moisture longer during baking.

The best single predictor of cookie diameter is sucrose SRC. The strong negative correlation of sucrose SRC to cookie diameter ($r=-0.66$, $p<0.0001$) has led to its adoption in lieu of baking cookies for most samples. The best prediction model for cookie diameter among grain samples milled on the Quadrumat advanced system uses a combination of sucrose SRC, softness equivalent, and flour protein ($R^2=0.61$). These three measures are combined into the baking quality score used in Quad Micro milling with the baking quality score favoring lower sucrose SRC and flour protein and greater softness equivalent values.

Cultivars that possess excellent milling properties nearly always produce large diameter cookie spreads. Poor milling cultivars nearly always produce smaller cookie spreads. Cultivars that are very soft in granulation usually produce good cookie spreads.

**AACC Method 10-52: Baking Quality of Cookie Flour** - Micro Method
Approved December, 2008
Meera Kweon, Research Food Technologist, Campbell Soup Corp

**Objective**
In North America, a "cookie" is a product similar to what is internationally known as a "biscuit". Cookie quality of flour is determined by the interaction among endogenous components of the flour and the ingredients in the mix. This method establishes a carefully controlled competition for water among the various components and ingredients, the results of which are manifest as differing cookie diameters. Larger diameter cookies are preferred and an indicator of good pastry-making and specifically cookie-baking potential. The method is also useful to evaluate other flour types, various flour treatments and other factors, such as ingredients, that affect cookie geometry.

**Apparatus**
1. National cookie dough micromixer, with head speed of 172 rpm and special cookie dough bowl.
2. Electric mixer, with timer control (Hobart or Kitchen-Aide), with paddle attachment.
3. Aluminum cookie sheet. See note 1.
4. Rolling pin, 5.7 - 7 cm (2.25 - 2.75 in.) diameter. If wood, check for wear to edges from use and replace if necessary.
5. Cookie cutter, 60 mm inside diameter.
6. Small plastic spatula, ground flat at end, with notch cut to fit cookie dough bowl and mixing head pins.
7. Thermometer and humidity meter / hygrometer. See note 2.
8. Baking oven, reel or rotary, electrically heated and capable of maintaining temperature of 205ºC ± 2º (400ºF ± 4º). See note 3.
9. Measuring calipers (large enough to measure 22 cm)

**Reagents**
1. Solution A. 0.95 M sodium bicarbonate (79.8 g dissolved in water to make 1L).
2. Solution B. 1.9 M ammonium chloride / 1.52 M sodium chloride (101.6 g and 88.8 g respectively, dissolved in water to make 1 L).
3. Sucrose. Any brand of "Baker's Special" sugar: sugar passing through a US No.30 sieve (595 µm openings) only. Particle size affects solubility.
4. Shortening. Non-trans fat, vegetable shortening not containing methyl silicone of medium consistency (e.g. Crisco non-trans fat shortening).
5. Nonfat dry milk. To pass through a US No. 30 sieve (595 µm openings).

**Procedure**

The total formulation amounts of each cookie pair are listed in Table 18.

1. Sift dry ingredients (sucrose, nonfat dry milk, dry sodium bicarbonate; Table 19 for sufficient creamed mass for different batch sizes, 21-46 cookie pairs; 37.60 g for each pair) together until well-mixed. Cream these ingredients together with shortening using Hobart or Kitchen-Aide mixer, using a paddle attachment, on low speed 1 min, then scrape bowl and paddle; on medium speed 1 min, then scrape; on high speed 30 sec, then scrape; and on high speed 30 sec. Weigh 37.60 g portions of this creamed mass for each cookie-pair to be baked.

2. Scrape measured creamed mass into cookie dough mixing bowl (National cookie dough micro-mixer, using a cookie dough bowl; head speed 172 rpm). Add water as shown in Tables 18 and 20: add 4.0 mL solution A, 2.0 mL solution B, and additional water (use water amount in Table 20 for appropriate flour moisture; 8.7 mL total water per cookie pair). Mix 3 min (stopping mixer and scraping after first few sec if shortening is stuck on side of bowl) and scrape with small spatula.

3. Add 40 g flour (14% mb, weight per Table 20) to mixing bowl. Mix a total of 25 sec. as follows: Mix for the first 10 sec while tapping side of bowl. Scrape dough from mixer and bowl pins; scrape outer edge and bottom of bowl, pushing dough between pins several times. Mix 5 sec and scrape as just described. Mix 5 sec and scrape. Mix 5 sec and scrape mixer pins.

4. Gently scrape dough from bowl, gently form into a single dough mass and cut with spatula into two equal portions. Transfer to a room-temperature cookie sheet with gauge strips. Roll to thickness with one forward and one backward stroke of rolling pin. Cut dough with cookie cutter, discard excess dough, and remove cutter.

5. Immediately place in oven and bake for 10 min. Remove sheet from oven. Cool 5 min and remove cookies from baking sheet.

6. After cookies have cooled to room temperature (at least 30 min), measure cookie diameter using calipers, or image analysis. Lay two cookies edge-to-edge and measure width. Rotate one cookie 90º, the other 45º. Measure again. Rotate both cookies 90º and measure again. Repeat. Average the four readings and divide by two to obtain average diameter of one cookie.

**Notes**

1. Aluminum cookie sheets made of 3003-H14 aluminum alloy, 2.0 mm (0.08 in) thick, 30.5 X 40.6 cm (12 X 16 in) or 25.4 X 33.0 cm (10 X 13 in), or other sizes required to accommodate oven doors and shelves. Cookie sheets should be manufactured with gauge strips fastened to the long edges of the sheets (gauge strips made of the same alloy as the sheets, 7 mm (0.275 in) thick and the length of the baking sheets). New sheets should be conditioned by lightly greasing and placing in hot oven for 15 min, cooling, and repeating the process two or three times. Cookie sheets should have excess grease wiped off after each cookie pair is baked. Cookie sheets should be washed while warm in water (without use of soap or detergent) and wiped dry after each bake.

2. Dough consistency, stickiness and cookie spread are affected by temperature and humidity. Room and ingredient temperature and humidity should be maintained at constant level among bakes (21ºC ± 1º (70ºF ± 2º) and 30 - 50% are recommended, respectively). Consistent environmental conditions are more important in a lab than adherence to a particular level, within reason.

3. Oven should have a hearth consisting of ceramic-fiber-reinforced structural alumina refractory product (6.4 mm (0.25 in)) thick as shelf liner cut to dimensions of and placed on the steel baking shelf. Oven shelves consisting of wire mesh baking surface are also suitable and may not need shelf liner (to prevent excessive bottom browning).

4. For relatively consistent mixing action, recommended cream mass batch size is 21 - 46 units. Obtain amounts of sugar, nonfat dry milk, sodium bicarbonate and shortening from Table 18.

5. Oven should be heated to temperature with oven shelves turning. Bake “dummy” cookies out of scrap dough or extra flour to condition the oven before beginning a test bake, at the beginning of a baking series, or if the oven has not been used for 15 min or longer.

**References**

Bettge, A.D. and Kweon, M. 2009. Report on collaborative testing of AACCI Method 10-52: Baking quality of cookie flour - micro method. Cereal Foods World.

Finney, K.F., Yamazaki, W.T., and Morris, V.H. 1950. Effects of varying quantities of sugar, shortening and ammonium bicarbonate on the spreading and top grain of sugar-snap cookies. Cereal Chem. 27:30.

Gaines, C.S. 1982. Influence of ambient temperature, humidity and flour moisture content on stickiness and consistency in sugar-snap cookie doughs. Cereal Chem. 59:507.

Kissell, L.T., Marshall, D.B., and Yamazaki, W.T. 1971. Effect of variability in sugar granulation on the evaluation of flour cookie quality. Cereal Chem. 50:255.

**Table 18. AACC Method 10-52 Ingredient amounts per cookie pair**

| Ingredient | Amount |
|---|---|
| Flour (14% mb) | 40 g |
| Sucrose | 24 g |
| Nonfat dry milk | 1.2 g |
| $NaHCO_3$ | 0.40 g |
| $NaHCO_3$ (in Soln A) | 0.32 g (in 4 mL) |
| $NH_4Cl$ (in Soln A) | 0.20 g (in 2 mL) |
| NaCl (in Soln B) | 0.18 g |
| Shortening | 12.0 g |
| Added Water[1] | 2.7 mL |

[1]Based on moisture of flour, adjusted water was added (see table 20)

**Table 19. AACC Method 10-52 Ingredient weights for batch preparation.**

Ingredient weights (g) for preparing creamed mass for different batch sizes

| Ingredient | 20 | 25 | 30 | 35 | 40 | 45 |
|---|---|---|---|---|---|---|
| Sucrose[1] | 504.0 | 624.0 | 744.0 | 864.0 | 984.0 | 1104.0 |
| Nonfat dry milk | 25.2 | 31.2 | 37.2 | 43.2 | 49.2 | 55.2 |
| Sodium bicarbonate | 8.4 | 10.4 | 12.4 | 14.4 | 16.4 | 18.4 |
| Shortening | 252.0 | 312.0 | 372.0 | 432.0 | 492.0 | 552.0 |

**Table 20. AACC Method 10-52 Calculated amounts of flour and added water for cookie test formula.**

| Flour moisture (%) | Added Water (g or mL) | Flour (g) | Flour moisture (%) | Added Water (g or mL) | Flour (g) |
|---|---|---|---|---|---|
| 9.1 | 4.9 | 37.8 | 12.1 | 3.6 | 39.1 |
| 9.2 | 4.9 | 37.8 | 12.2 | 3.5 | 39.2 |
| 9.3 | 4.8 | 37.9 | 12.3 | 3.5 | 39.2 |
| 9.4 | 4.7 | 38.0 | 12.4 | 3.4 | 39.3 |
| 9.5 | 4.7 | 38.0 | 12.5 | 3.4 | 39.3 |
| 9.6 | 4.6 | 38.1 | 12.6 | 3.3 | 39.4 |
| 9.7 | 4.6 | 38.1 | 12.7 | 3.3 | 39.4 |
| 9.8 | 4.6 | 38.1 | 12.8 | 3.3 | 39.4 |
| 9.9 | 4.5 | 38.2 | 12.9 | 3.2 | 39.5 |
| 10.0 | 4.5 | 38.2 | 13.0 | 3.2 | 39.5 |
| 10.1 | 4.4 | 38.3 | 13.1 | 3.1 | 39.6 |
| 10.2 | 4.4 | 38.3 | 13.2 | 3.1 | 39.6 |
| 10.3 | 4.3 | 38.4 | 13.3 | 3.0 | 39.7 |
| 10.4 | 4.3 | 38.4 | 13.4 | 3.0 | 39.7 |
| 10.5 | 4.3 | 38.4 | 13.5 | 2.9 | 39.8 |
| 10.6 | 4.2 | 38.5 | 13.6 | 2.9 | 39.8 |
| 10.7 | 4.2 | 38.5 | 13.7 | 2.8 | 39.9 |
| 10.8 | 4.1 | 38.6 | 13.8 | 2.8 | 39.9 |
| 10.9 | 4.1 | 38.6 | 13.9 | 2.7 | 40.0 |
| 11.0 | 4.0 | 38.7 | 14.0 | 2.7 | 40.0 |
| 11.1 | 4.0 | 38.7 | 14.1 | 2.7 | 40.0 |
| 11.2 | 4.0 | 38.7 | 14.2 | 2.6 | 40.1 |
| 11.3 | 3.9 | 38.8 | 14.3 | 2.6 | 40.1 |
| 11.4 | 3.9 | 38.8 | 14.4 | 2.5 | 40.2 |
| 11.5 | 3.8 | 38.9 | 14.5 | 2.5 | 40.2 |
| 11.6 | 3.8 | 38.9 | 14.6 | 2.4 | 40.3 |
| 11.7 | 3.7 | 39.0 | 14.7 | 2.4 | 40.3 |
| 11.8 | 3.7 | 39.0 | 14.8 | 2.3 | 40.4 |
| 11.9 | 3.7 | 39.0 | 14.9 | 2.3 | 40.4 |
| 12.0 | 3.6 | 39.1 | 15.0 | 2.2 | 40.5 |

## New Method – Chemically-leavened cracker baking procedure

Developed by Meera Kweon,Research Food Technologist, Campbell Soup Corp

**Background**

Traditionally, the baking performance of soft wheat flours has been evaluated by well-established, benchtop cookie-baking methods (e.g. AACC Approved Methods 10-52 and 10-53 (AACC International 2000)). In contrast, a benchtop cracker-baking method has not been widely explored or implemented as an official method, due to hurdles including the difficulty in finding ideal diagnostic flours and the absence of suitable benchtop equipment (e.g. powerful dough mixer, dough sheeter, multi-zone oven).

There are generally three major types of crackers: saltine, chemically-leavened, and savory. The typical processes for preparing saltine and savory crackers usually require about 24 hours, due to a prolonged fermentation time. In comparison, chemically-leavened crackers ordinarily do not require a fermentation step, and their processing is relatively easy and simple to manage. Development of a benchtop method for chemically-leavened crackers would enable one to use such a method as a predictive tool for evaluating gluten functionality in flour for crackers.

Soft wheat flours with greater gluten strength are typically preferred for commercial cracker production. The purpose of developing a benchtop baking method is to predict the contribution of gluten functionality to overall flour performance for chemically-leavened crackers.

**Apparatus**

1. Pin mixer (National Manufacturing Co.), with head speed of 102 rpm and a 100g flour batch dough bowl.
2. Dough sheeter (Model SFB 528, width of sheeting rolls, 19 5/8”, Univex Corp., Salem, NH)
3. Hand cutter (2.25 x 1.65 in, 7 docker pins, Weidenmiller Co., Itasca, IL)
4. Baking mesh (cord-weave, 13L x 10W in, 0.26 in thickness, Hi Carbon Steel, spec. C-100-3F, Audubon, Feasterville, PA)
5. Baking (cooling) rack
6. Aluminum cookie baking sheet.
7. Baking oven, reel or rotary, electrically heated and capable of maintaining temperature of 500ºF ± 5º).
8. Measuring calipers

**Basic ingredients and formula**

| Ingredient | Formula (g) |
|---|---|
| Flour | 100.0 (14% moist.) |
| Fine granulated sucrose | 9 |
| Salt | 0.75 |
| Sodium bicarbonate | 1.25 |
| Ammonium bicarbonate | 1.25 |
| Monocalcium phosphate (MCP monohydrate) | 1.25 |
| Shortening | 12.0 |
| Water | 29.0 |

**Mixing procedure**

Stage 1:

1) Dissolve fine granulated sucrose in water to prepare a pre-dissolved sugar solution.
2) Weigh 38g of pre-dissolved sugar solution into a 100g pin mixer mixing bowl at room temperature and add ammonium bicarbonate to dissolve.
3) Add room temperature shortening.
4) Mix 1 min.

Stage 2:

1) Add pre-weighed flour, salt, sodium bicarbonate, and monocalcium phosphate.
2) Mix 10 min continuously.
3) Use dough to make a dough ball.

**Sheeting procedure**

1) Make a dough ball with hands, and flatten it for sheeting.
2) The sheeted dough is sheeted at dial setting “5” (5.59mm) of the Univex sheeter.
3) Change the sheeting direction knob to the opposite direction and sheet the dough at dial setting “3” (3.78mm).
4) Repeat step 3 three times with dial settings “2” (2.71mm), “1” (1.77mm), and 2$^{nd}$ smallest (0.54mm), sequentially.
5) The sheeted dough is rested for 1 min on the sheeter belt, and dough pieces are cut with a hand cutter (4 pieces of cracker dough) twice to prepare 8 pieces of cracker dough.
6) The 8 pieces of cracker dough are transferred to a cookie baking sheet, and total dough weight is measured before transferring the dough pieces to pre-heated baking mesh.

**Baking procedure**

Oven temperature: set 500°F (260°C)

Baking time: about 5-6 min (Target moisture: 2.75% (2.0-3.5%))

1) A cracker baking mesh is placed on the top of a baking (cooling) rack, and pre-heated in an oven for 5 min before sheeting dough.
2) Cut cracker dough pieces are placed on pre-heated baking mesh, and placed in an oven for baking.
3) Baked crackers are removed from the oven, and transferred to the cookie baking sheet to measure the cracker weight.
4) Moisture loss during baking is calculated.
5) Length, width and height are measured for 8 crackers, and the average length, width and height are reported.

# Micro Assay for Flour Alpha Amylase Activity

Adapted by Mary Guttieri for the Soft Wheat Quality Laboratory

The new method adapts the AACC Method 22-02 using the Ceralpha K-CERA (Megazyme) alpha-amylase assay procedure for higher throughput to determine flour alpha-amylase activity in a microwell plate. All reagents, controls and precautions are as described in the Megazyme manual.

**Required Materials**

- Ceralpha Alpha-Amylase Kit (AACC Method 22-02)
- 50 mL conical centrifuge tubes
- Centrifuge with rotor to spin 50 mL conical tubes at 1000 xg
- Analytical balance
- Microplate reader and plate (510 nm)
- Vortex mixer
- Water bath at 40$^{o}$ C
- Multichannel repeating pipette

**Ceralpha Substrate and Stopping Reagent**

Ceralpha substrate is prepared as described and stored frozen (-20$^{o}$C) in 1 mL aliquots in microcentrifuge tubes.

Additional Stopping Reagent is prepared using 1% w/v sodium phosphate tribasic dodecahydrate in distilled water adjusted to pH11.

**Enzyme Extraction**

1. Accurately weigh 3.0 g of ground grain or flour into a 50 mL conical centrifuge tube.
2. Add 20.0 mL of 1X Extraction Buffer solution (pH 5.4) to each tube and mix vigorously.
3. Allow enzyme to extract over 20 minutes in a 40°C water bath, with occasional mixing.
4. Centrifuge 1,000 x *g* for ten minutes.
5. Assay enzyme activity within two hours.

**Reaction Blank**

A single set of triplicate Reaction Blanks (non-enzymatic control) is prepared as follows for each batch of samples being analyzed.

1. 0.3 mL of stopping reagent
2. 20 μL of substrate solution at the start of the reaction time
3. 20 μL of any enzyme preparation in the sample set

The mean absorbance of the non-enzymatic control is subtracted from all assays conducted during that day to establish the background or blank absorbance.

**Assay Procedure**

1. Dispense 20 μL aliquots of Ceralpha Reagent Solution into a microtiter plate and pre-incubate the tubes and contents at 40°C for 5 min. Dispense 3 aliquots for each enzyme extract (assay each extract in triplicate).
2. To each well containing Ceralpha Reagent solution (20 μL), add 20 μL of wheat α-amylase extract directly to the bottom of the well at 30 second intervals.
3. Incubate at 40°C for exactly twenty min from time of addition.
4. Following the 20 min incubation period, add exactly 0.3 mL of Stopping Reagent.
5. Read the absorbance of the solutions and the reaction blank at 400 nm against 340 μL distilled water.

## New Method – Soft Wheat Whole Grain NIR (DA 7200)

Prepared by William Wade, USDA-SWQL, Wooster, OH
* Calibration files for the DA 7200 are available upon request.

1. Turn on DA7200
   a. Power-up (small toggle switch on back by power cord).
   b. Log in.
   c. Start *SIMPLICITY FOR DA7200*.
   d. Allow to warm up for 30 minutes.

2. Collect equipment: sample cups and level bar.

3. Select the Product “Soft Wheat Grain”.

4. Prepare first sample in sample cup; slightly overfill sample to ensure that after leveling off, sample is flush with the top of the sample cup. (If there is not enough sample to fill the cup, place the black riser inside the cup first. If there is still not enough to have the sample flush with the top of the cup, the sample is unable to be analyzed on this machine.)

5. Level off the sample cup and place inside the machine. (Note: there are two size cups; with the small cup the platter will need to be pushed in, with the large cup it will need to be pulled out.)

6. Start analysis:
   a. Barcode: Scan the barcode of the first sample. This will start the analysis.
   b. No Barcodes: Enter a unique identifier (sample name) in the Sample text area and press *ENTER*.

7. When requested, repack the cup by pouring out the current cup and refilling. Always re-level sample.

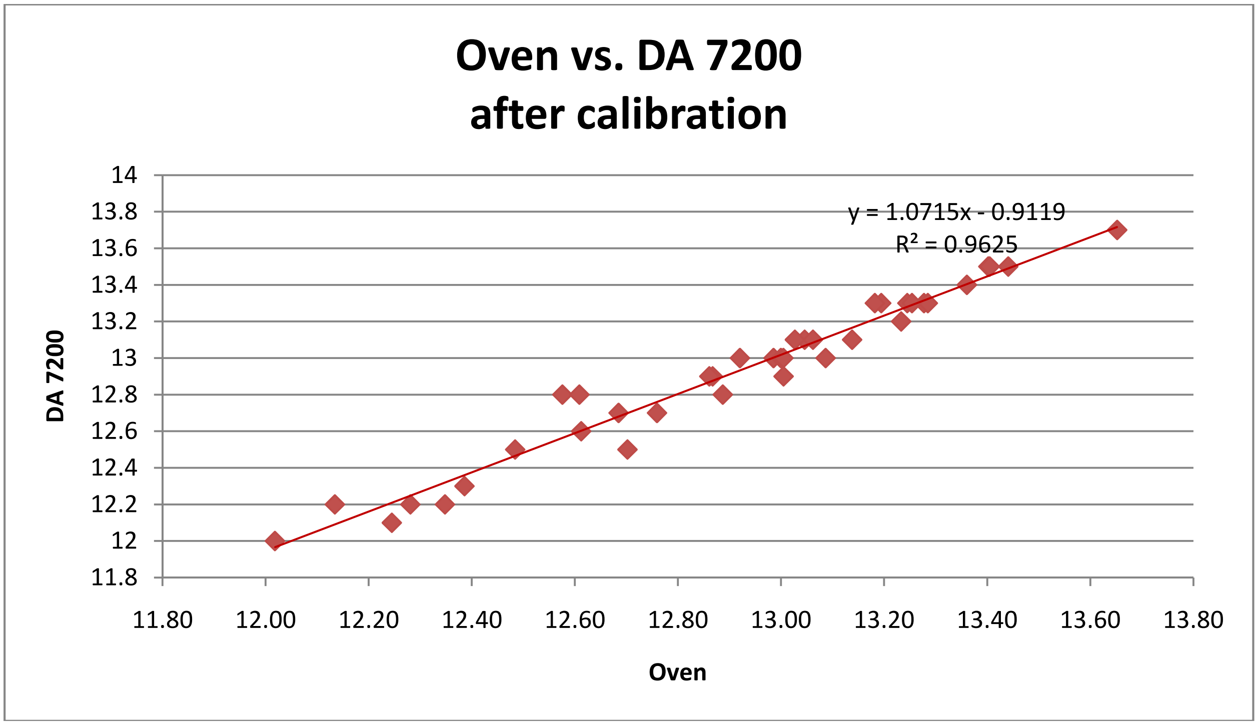
8. Repeat steps 4-7 as needed.

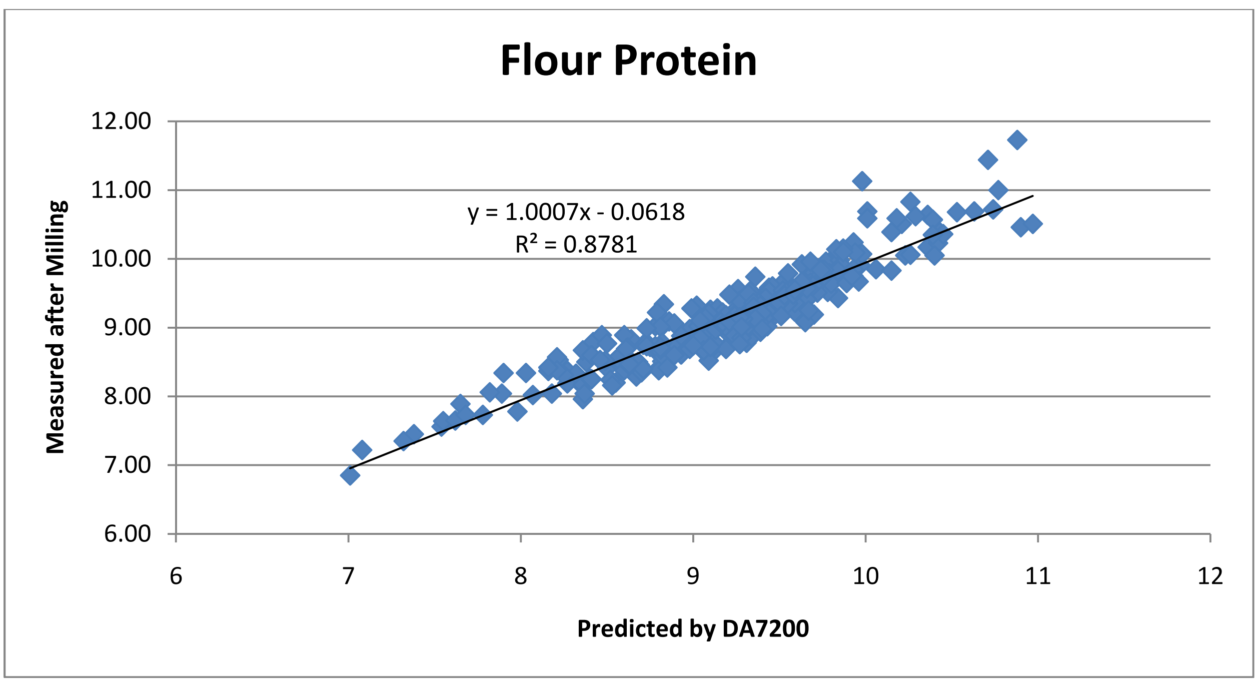
9. Exit the program and shutdown the machine if done for the day.

10. Transfer to Database
    a. Logon to the Database.
    b. Go to the group page and select Import Sample Traits.
    c. Click the link “DA 7200” under Auto import.
    d. If there are duplicates, it will ask which one you want.
    e. Confirm data imported.

11. Retrieve Data Directly:
    a. Copy the file from “C:\pda7200\nirresults\Soft Wheat Grain.csv” to a place on a network drive.
    b. From another computer, open Soft Wheat Grain.csv and delete any entries from earlier runs.
    c. Save data

# Graphs of Two Calibrations



# New Method – Advanced Mill Database Creation
**Edward Souza, SWQL, February 22, 2011**

**Purpose**
To summarize cultivar milling and baking data into a reference for use in adjusting other data sets of experimental lines.
Current Advanced Mill Database: Advanced Database Means Feb 24 2011.xlsx

**Background**
Each group germplasm from breeders that is evaluated by the laboratory should have check cultivars included in the group. As part of the validation process of the data, those checks should be compared to prior performance of the check in quality evaluations. Environmentally adjusted scores are created for each line evaluated in the laboratory. This is calculated based on the difference between an historical average of the cultivar's performance and the observed value within the trial. The Advanced Mill Database is the tabular form of historical averages for cultivars evaluated at the laboratory using the modified Quadrumat flour mill.

**Compilation of Data**
Databases of previous year's performance are compiled and stored on the SWQL server in the folder marked 'Quality Scores'. Begin with the most recent and add to it all new advanced groups evaluated in the laboratory since the last compilation. The dataset as of 2/22/2011 bridges evaluations with the current and earlier sugar-snap cookie method. Samples evaluated with the earlier method are noted in a method column with 'Old'. All current data should be marked as 'New' for the method column as we are using the revised sugar-snap cookie method exclusively since 2009. Edit previous entries of new cultivar releases in the past year for consistent naming. Review all naming for consistency as company names can and do change each year.

**Analysis of Data**
Due to the unbalanced nature of the data, we can only generate approximate means.

1. The current model used includes 'year' of testing and 'cult' or cultivar name as the independent variables to generate a least squares mean.
2. Any entries that appear fewer than seven times in the database should not be analyzed.
3. Mean values for each cultivar as well as the number of observations contributing to the mean are tabled for use in adjustments. Milling, baking, and softness equivalent scores are included in the table and graded.
4. Cookie data has a more complex model; it includes a third variable of 'method' to specify the different baking methods. The new method produces cookies approximately 0.6 cm greater in diameter than the earlier method.
5. When cookie means are entered into the database table, the average value should be increased by half the difference between the two methods so that the

value appearing in the table is close to the values produced under the current baking method.

6. Regression models for generating scores are created by modeling the mean scores against the mean milling and baking data for the cultivars in the Advanced Mill Database. Using the means in the table, SAS should solve the regression models:

Milling score = Intercept + b*Milling yield

Baking score = Intercept + b1*Cookie diameter + b2*Sucrose SRC + b3*Softness equivalent

Softness equivalent score = Intercept + b*Softness equivalent

Milling and baking data analysis uses the models in the templates sheets marked ‘Adjustment Factor’ sheet to calculate the observed scores for the checks. The observed scores are compared to the historical averages for the checks in the Advanced Mill Database, and the difference is used to calculate the bias for adjusting the scores of experimental lines. The bias attempts to adjust for environmental influences on the trial to produce environmentally neutral scores for milling, baking, and softness equivalent.

**Annotation of the Set**

The data sheets should note averages of all entries and standard errors for a specified number of observations. The raw data used to generate the means should be annotated for date of last entry and any missing or unusual information in the group. Backups should be made on the local computer and server. All technicians should be informed of the conversion to the new database. In the database and in files a date should be noted for conversion to the new database. Each group processed should be marked at the bottom with the version of the database used for analysis.

# Milling Formulas Used for SWQL Reports

## Micro Milling

**Grain Moisture Estimate**
Grain moisture = 1.3429 x (flour moisture) – 4

**Estimated Flour Yield Corrected to 15% Moisture**
Flour Yield$_{(15\%)}$ = Flour Yield$_{(\text{as is})}$ - 1.61% x (15% - Actual flour moisture)

**Softness Equivalent (SE)**
SE$_{(\text{as is})}$ = ((GW - Bran) - Mids)/(GW - Bran)
Where:
SE = Softness Equivalent
GW = Weight of grain milled
Bran = Weight of milled product that remains above a 40 mesh screen
Mids = Weight of mill product through a 40 mesh and remaining above a 94 mesh screen

**Softness Equivalent at 15% grain moisture (SE$_{15\%}$)**
SE$_{(15\%)}$ = SE$_{(\text{as is})}$ - 1.08% x (15% - Actual flour moisture)

**Flour yield adjustment[11]**
Adjusted Flour Yield = Flour Yield$_{(15\%)}$ + 0.17 x (Softness Equivalent$_{(15\%)}$ - 52%)

**Milling Quality Score (MQS)**
MQS = MF + (5.0144 x Adjusted Flour Yield) -292.6425
Where:
MF = Allis Milling Score - (5.0144 x SAFY) - 292.6425
Allis Milling Score = Mill score from Allis database for the quality standard designated for the group
SAFY = Adjusted Flour Yield for the quality standard designated for the trial as measured in the trial being evaluated

[11] On the small Quad Mill, coarser type soft wheat samples will appear to mill better than they should and conversely, softer type soft wheat samples will have suppressed "as is" flour yields. When compared to soft wheat samples with lower softness equivalents, wheat samples with higher softness equivalents typically require greater break roll milling to completely separate endosperm from bran. Micro milling adjustments were developed by Lonnie Andrews with Patrick Finney and Charles Gaines. Additional details are included in the Standard Operating Procedures for the Soft Wheat Quality Laboratory.

**Baking Quality Score (BQS)**
BQS = BF + (33.3333*CS) - 526.667
Where:
BF = Allis Baking Score – SCS
CS = Cookie Score = (-0.145 x Flour Protein) + (-0.07 x Sucrose SRC) + (0.049 x SE) + 21.9
SCS = Standard Cookie Score – cookie score for the quality standard designated for the trial as measured in the trial being evaluated
Allis Baking Score = Allis baking score for the quality standard as determined in the Allis Milling Database

## Advanced Flour Milling

All formulas for Advanced milling are the same as Micro milling with the exception of Baking Quality Score.

**Baking Quality Score (BQS)**
BQS = (33.33333 x Cookie Diameter) - 526.667 + BF
Where:
BF = Baking Factor = Allis Bake Score - (33.33333 x SCD) - 526.667
Allis Baking Score = Allis baking score for the quality standard as determined in the Allis Milling Database
SCD = Standard Cookie Diameter – cookie diameter for the quality standard designated for the trial as measured in the trial being evaluated

## Allis-Chalmers Flour Milling

**Recovery Weight**
Recovery Wt. = Bran Wt. + Red Dog Wt. + Shorts Wt. + Straight Grade Wt.

**Flour Yield**
Flour yield = Straight Grade Wt. / Recovery Wt.

**Endosperm Separation Index (ESI)**
ESI= [(Bran Wt. + Red Dog Wt. + Shorts Wt.) / Recovery Wt] - 17. [12]

**Friability**
Friability = (Summed weight of material milled by 2nd to 6th Break and 1st to 7th Reduction) / Weight of straight grade flour

[12] In practice the recovery weight is estimated at 98% of milled weight

**Allis Softness Equivalent (Allis SE)**
Allis SE = Break Flour % + 21%

**Allis Milling Score**
Allis milling score = 33.3 – [80 - Allis straight grade flour yield) x 3.7]
+ 33.6 + [(6 - ESI) x 2.8]
+ 33 - [32 - Friability) x 3.3]

**Allis Baking Score**
Allis Baking Score = (33.33333 x Cookie Diameter) - 526.66

# Quality Genotyping

The markers listed below and other published assays for wheat evaluation can be referenced at the Wheat Cap website under the "MAS protocols" section: **http://maswheat.ucdavis.edu/index.htm**

SSR markers were accessed from the GrainGenes website: **http://wheat.pw.usda.gov/GG2/index.shtml**

**Table 21. Commonly used PCR markers for testing wheat quality at the Soft Wheat Quality Laboratory**

| Primers | Sequence | Product | RXN |
|---|---|---|---|
| | High Molecular Weight Glutenins | | |
| GluA1 | (Zhang, 2003) | | |
| AxFwd | ATGACTAAGCGGTTGGTTCTT | 1,200 | 58°C |
| Ax2* (reverse) | ACCTTGCTCCCCTTGTCTTT | | |
| Ax1 (reverse) | ACCTTGCTCCCCTTGTCCTG | | |
| GluD1 | (Guttieri, 2008), (Wan, 2005) | | Touch |
| DxL_151 (forward) | AGGATTACGCCGATTACGTG | | Down* |
| Dx2R (reverse) | AGTATGAAACCTGCTGCGGAG | 664 | 2+12 |
| Dx5R (reverse) | AGTATGAAACCTGCTGCGGAC | | 5+10 |
| GluB1 | (Z.A., 2006) | | |
| Glu1By8_F5 | TTAGCGCTAAGTGCCGTCT | 527 | 64°C |
| Glu1B_R5 | TTGTCCTATTTGCTGCCCTT | | |
| Glu1By9_F1 | TTCTCTGCATCAGTCAGGA | 662 / 707 | 59°C |
| Glu1B_R3 | AGAGAAGCTGTGTAATGCC | | |
| Glu1By9_F7 | TACCCAGCTTCTCAGCAG | 0/2/3 | 59°C |
| Glu1B_R6 | TTGTCCCGACTGTTGTGG | bands | |
| Glu1By9_F2 | GCAGTACCCAGCTTCTCAA | 0/2/3 | 62°C |
| Glu1B_R2 | CCTTGTCTTGTTTGTTGCC | bands | |
| Bx7 over-expression | (Guttieri, 2008) | | |
| Bx7oe_L1 | GCGCGCTCAACTCTTCTAGT | 404 / 447 | 64°C |
| Bx7oe_R1 | CCTCCATAGACGACGCACTT | | |
| | Low Molecular Weight Glutenins | | |
| | (Zhang W. G., 2004) | | |
| GluA3F1 | GTACGCTTTTGTAGCTTGTGC | 1,414 | 59°C |

| Primers | Sequence | Product | RXN |
|---|---|---|---|
| GluA3R1 | TCCATCGACTAAACAACGGAGA | | |
| GluA3F1 | As above | 1,346 | 59°C |
| GluA3R2 | GATGCCAACGCCTAATGGCACAC | | |
| GluA3F1 | As above | 596 | 59°C |
| GluA3aR | TGGTGGTTGTTGTTGTTGCTACA | | |
| GluA3bF | CACAATTTTCACAGCAACAGCAG | 823 | 59°C |
| GluA3bR | GGCACATTGACACTACACATTG | | |
| GluA3bF | As above | 196 | 59°C |
| GluA3cR | TTGGTGGCTGTTGTGAAGACGA | | |
| GluA3dF | ACCAGTTATTCATCCATCTGCTC | 488 | 59°C |
| GluA3dR | GTGGTTTCGTACAACGGCTCG | | |
| GluA3eF | CAATGAAAACCTTCCTCGTCTG | 1,151 | 59°C |
| GluA3R2 | As above | | |
| GluA3F1 | As above | 1,101 | 59°C |
| GluA3fR | GTTGCTGCTACAACTGCTGTA | | |
| GluA3gF | CAGCAGCCACCACATTCGCAA | 861 | 59°C |
| GluA3R2 | As above | | |
| Gliadins | (Ma, 2003) | | |
| GligDF1 | AAGCGATTGCCAAGTGATGCG | 264 | 56°C |
| GligDR1 | GTTTGCAACACCAATGACGTA | | |
| GligDF1 | AAGCGATTGCCAAGTGATGCG | 270 | 56°C |
| GligDR2 | GCAAGAGTTTGCAACAGCG | | |
| Rye translocation | (de Froidmond, 1998) | | Touch |
| O11B3 | GTTGCTGCTGAGGTTGGTTC | | Down* |
| O11B5 | GGTACCAACAACAACAACCC | 412 | |
| SECA2 | GTTTGCTGGGGAATTATTTG | | |
| SECA3 | TCCTCATCTTTGTCCTCGCC | 632 | |
| 1B/1R & 1A/1R | (Saal, 1999) | | |
| SCM9_L_M13 | CACGACGTTGTAAAACGACTGACAACCCCCTTTCCCTCGT | 227/243 | Tailed |
| SCM9_R | TCATCGACGCTAAGGAGGACCC | | Reaction* |
| Waxy - GBSS | (Nakamura, 2002) | | |
| AFC | TCGTGTTCGTCGGCGCCGAGATGG | 425, 455, 497 | 65°C |
| AR2 | CCGCGCTTGTAGCAGTGGAAGTACC | | |
| BDFL | CTGGCCTGCTACCTCAAGAGCAACT | 370, 389, | 65°C |
| BRD | CTGACGTCCATGCCGTTGACGA | 410,408 | |
| BDFL | CTGGCCTGCTACCTCAAGAGCAACT | 1,731, 2,307 | 65°C |

| Primers | Sequence | Product | RXN |
|---|---|---|---|
| DRSL | CTGTTTCACCATGATCGCTCCCCTT | | |
| Tailed | Better to use M13-tailed AFC and BRD, analyze via capillary electrophoresis | | |
| AFC_M13 | **CACGACGTTGTAAAACGAC**TCGTGTTCGTCGGCGCCGAGATGG | | |
| BDFL_M13 | **CACGACGTTGTAAAACGAC**CTGGCCTGCTACCTCAAGAGCAACT | | |
| Pre-harvest sprouting | (Yang, 2007) | | |
| Vp1BF | TGCTCCTTTCCCAATTGG | 652 | 61$^{o}$C |
| Vp1BR | ACCCTCCTGCAGCTCATTG | 569, 845 | Tolerant |

## Genotyping Bibliography


Beales, J. T. (2007). A Pseudo-Response Regulator is misexpressed in the photoperiod insensitive Ppd-D1a mutant of wheat (Triticum aestivum L.),. *TAG* (115), 721-733.

de Froidmond, D. (1998). A Co-dominant Marker for the 1BL/1RS Wheat-rye Translocation via Multiplex PCR. *J. Cereal Sci* (27), 229-232.

Guttieri, M. S. (2008). Optimized PCR Primer Set for Determining Gluten Strength Qulaity in Soft Wheat Germplasm. *PAG poster* .

Lei, Z. (2006). Y-type gene specific markers for enhanced discrimination of high-molecular weight glutenin alleles at the Glu-B1 locus in hexaploid wheat. *J Cereal Sci* (43), 94-101.

Liu, S. C. (2008). New DNA markers for high molecular weight glutenin subunits in wheat. *Theor Appl Genet* (118), 177-183.

Liu, S. P. (2008). Toward positional cloining of FHB1, a major QTL for fusarium head blight resistance in wheat. *Third International FHB Symposium* .

Ma, W. Z. (2003). Multiplex-PCR typing of high molecular weight glutenin alleles in wheat. *Euphytica* (134), 51-60.

McCartney, C. S. (2007). The evaluation of FHB resistance QTLs introgressed into elite Canadian spring wheat germplasm. *Mol Breeding* (20), 209-221.

Nakamura, T. P. (2002). Rapid classification of partial waxy wheats using PCR-based markers. *Genome* (45), 1150-1156.

Saal, B. a. (1999). Development of simple sequence repeat markers in rye (Secale cereale L.). *Genome* (42), 964-972.

Tsilo, T. J. (2008). Diagnostic Microsatellite Markers for the Detection of Stem Rust Resistance Gene Sr36 in Diverse Genetic Backgrounds of Wheat. *Crop Sci.* (48), 253-261.

Wan, Y. Y. (2005). Comparative analysis of the D genome-encoded high-molecular weight subunits of glutenin. *TAG* (111), 1183-1190.

Yang, Y. Z. (2007). Development and validation of a Viviparous-1 STS marker for pre-harvest sprouting tolerance in Chineses wheates. *TAG* (115), 971-980.

Zhang, W. G. (2004). Characterisation and marker develoment for low molecular weight glutenin genes from Glu-A3 alleles of breat wheat (Triticum aestivum). *TAG* (108), 1409-1419.

Zhang, W. G. (2003). Identification of SNPs and development of allele-specific PR markers for γ-gliadin alleles in Triticum aestivum. *TAG* (107), 130-138.

Zhang, X. Y. (2006). Distribution of the Rht-B1b, Rht-D1b and Rht8 reduced height genes ib autumn-sown Chines wheats detected by molecular markers. *Euphytica* (152), 109-116.

# Soft Wheat Publications

Bettge, A. and Kweon, M. (2009) Collaborative study on updated method 10-52: Baking quality of cookie flour – micro method (sugar-snap cookie). Cereal Foods World 54: 70-73.

Bowen, D.E., E.J. Souza, M.J. Guttieri, V. Raboy, and J. Fu. (2007) A low phytic acid barley mutation alters seed gene expression. The Plant Genome 2: S-149 – S-159.

Bowen, D., M.J. Guttieri, K. Peterson, K. Peterson, V. Raboy, E. Souza (2007) Phosphorus Fractions in Developing Seeds of Four Low Phytate Barley (*Hordeum vulgare L.*) Genotypes. Crop Sci. 46: 2468-2473.

Delwiche, S., R.A. Graybosch, L.E. Hansen, E. Souza, and F.E. Dowell (2006) Single kernel near-infrared analysis of tetraploid (durum) wheat for classification of the waxy condition. Cereal Chem. 83: 287-292.

Fu, J., K. Peterson, M.J. Guttieri, E.J. Souza, and V. Raboy (2008) Barley (Hordeum vulgare L.) Inositol Monophosphatase: Gene Structure and Enzyme Characteristics. Plant Molecular Biology 67: 629-642.

Gaines, C.S., J. Fregeau Reid, C. Vander Kant, and C.F. Morris. (2006) Note: Comparison of methods for gluten strength assessment. Cereal Chem. 83: 284-286.

Guedira, M., G. Brown-Guedira, D. Van Sanford, C. Sneller, E. Souza and D. Marshall (2010) Distribution of *Rht* genes in winter wheat germplasm from the eastern and central United States. Crop Science 50:1811–1822.

Guttieri, M.J., E.J. Souza, C. Sneller (2011) Laboratory milling method for whole grain soft wheat flour evaluation. Cereal Chem. 88:1-5.

Guttieri. M.J., E.J. Souza, and C. Sneller (2008) Non-starch polysaccharides in wheat flour and wire-cut cookie making. Journal of Agricultural and Food Chemistry 56:10927-10932.

Guttieri, M. J., K. M. Peterson, and E. J. Souza (2006) Milling and Baking Quality of Low Phytic Acid Wheat. Crop Sci. 46: 2403-2408.

Guttieri, M. J., K. M. Peterson, and E. J. Souza (2006) Agronomic Performance of Low Phytic Acid Wheat. Crop Sci. 46: 2623-2629.

Guttieri, M. J., K. M. Peterson, and E. J. Souza. (2006) Mineral Distributions in Milling Fractions of Low Phytic Acid Wheat. Crop Sci. 46: 2692-2698.

Guttieri, M.J., K. O'Brien, C. Becker, J.C. Stark, J.M. Windes, and E. Souza (2006) Managing nitrogen fertility of irrigated soft white spring wheats for optimum quality. Can. J. Plant Sci. 86:459-464.

Guttieri, M.J., C. Becker, and E. Souza (2004) Application of wheat meal solvent retention capacity tests within soft wheat populations. Cereal Chem. 81: 261-266.

Guttieri, M.J., R. McLean, S.P. Lanning, L.E. Talbert, and E.J. Souza (2002) Assessing environmental influences on solvent retention capacity of two soft white spring wheat cultivars. Cereal Chem. 79: 880-884.

Guttieri, M.J., D. Bowen, D. Gannon, K. O'Brien, and E. Souza (2001) Solvent retention capacities of irrigated soft white spring wheat flours. Crop Sci. 41:1054-1061.

Hughes, K.R., C.A Griffey, D.J. Parrish, W.E. Barbeau, E. Souza and W.E. Thomason (2010) Pre-harvest sprouting tolerance in current soft red winter wheat cultivars. Crop Sci. 50: 1449-1457.

Knott, C.A., D.A. Van Sanford, and E.J. Souza (2009) Genetic Variation and the Effectiveness of Early-Generation Selection for Soft Winter Wheat Quality and Gluten Strength. Crop Sci. 49: 113-119.

Knott, C.A., D.A. Van Sanford, and E.J. Souza (2009) Genetic Variation and the Effectiveness of Early-Generation Selection for Soft Winter Wheat Quality and Gluten Strength. Crop Sci. 49: 113-119.

Knott, C.A., D.A. Van Sanford, and E.J. Souza (2008) Comparison of Selection Methods for the Development of White-Seeded Lines from Red x White Soft Winter Wheat Crosses. Crop Sci. 48: 1807-1816.

Kweon, M. L. Slade, H. Levine, and E. Souza (2010) Application of RVA and time-lapse photography to explore effects of extent of chlorination, milling extraction rate, and particle-size reduction of flour on cake-baking functionality. Cereal Chem. 87:409–414.

Kweon M., Donelson T., Slade L., Levine H. (2010) Micro-sugar-snap and micro-wire-cut cookie baking with trans-fat and zero-trans-fat shortenings. Cereal Chem. 87: 415-419.

Kweon M., Slade L., Levine H. (2009) Oxidative gelation of solvent-accessible arabinoxylans is the predominant consequence of extensive chlorination of soft wheat flour. Cereal Chem. 87: 421-424.

Kweon, M, Martin, R., and Souza, E. (2009) Effect of tempering conditions on milling performance and flour functionality. Cereal Chem. 86:12-17.

Kweon, M., Slade, L., Levine, H., Martin, R., Andrews, L., and Souza, E. (2009) Effects of extent of chlorination, extraction rate, and particle size reduction on flour and gluten functionality explored by solvent retention capacity (SRC) and mixograph. Cereal Chem. 86: 221-224.

Kweon, M., Slade, L.,and Levine, H. (2009) Oxidative gelation of solvent-accessible arabinoxylans is the predominant consequence of extensive chlorination of soft wheat flour. Cereal Chem. 86: 421-424.

Kweon, M., Slade, L.,Levine, H., Martin, R., and Souza, E. (2009) Exploration of sugar functionality in sugar-snap and wire-cut cookie baking: Implications for potential sucrose replacement or reduction. Cereal Chem. 86: 424-433.

Kweon, M. R., Slade, L., and Levine, H. (2008) Effect of sodium chloride on glassy and crystalline melting transitions of wheat starch treated with high hydrostatic pressure: prediction of solute-induced barostability from nonmonotonic solute-induced thermostability. Starch/Stärke 60: 127-133.

Nash, D. S.P. Lanning, P. Fox., J.M. Martin, N.K. Blake, E. Souza, R.A. Graybosch, M.J. Giroux, and L.E. Talbert (2006) Relationship of dough extensibility to dough strength in a spring wheat cross. Cereal Chem. 83: 255-258.

Sherman, J. D., E. Souza, D. See, and L. E. Talbert (2008) Microsatellite Markers for Kernel Color Genes in Wheat. Crop Sci. 48: 1419-1424.

Souza, E.J., M.J. Guttieri, C. Sneller (2011) Selecting soft wheat genotypes for whole grain cookies. Crop Science 51: 189–197.

Souza, E.J., C. Griffey, M. Kweon, and M. Guttieri (2008) Sources of Variation for Long-Flow Experimental Milling. Crop Sci. 48: 1432-1440.

Souza, E.J., J.M. Martin, M.J. Guttieri, K. O'Brien, D.K. Habernicht, S.P. Lanning, G.R. Carlson, and L.E. Talbert (2004) Influence of genotype, environment, and nitrogen management on spring wheat quality. Crop Sci. 44: 425-432.

Souza, E., R. Graybosch, and M.J. Guttieri (2002) Breeding for improved milling and baking quality in wheat; a review. Journal of Crop Production 5: 39-74.

## Soft Wheat Methods Related References


Experimental Milling of Soft Wheat Cultivars and Breeding Lines. Cereal Chemistry 59(1): 41-45.

Small-Scale Milling to Estimate the Milling Quality of Soft Wheat Cultivars and Breeding Lines. Cereal Chemistry 59(4): 270-272.

Distribution of Deoxynivalenol in Soft Wheat Mill Streams. Cereal Chemistry 62(6): 467-469.

A Thirty-Minute Conditioning Method for Experimental Milling of Soft Wheat. Cereal Chemistry 63(1): 18-21.

Revised Micro Testing for Soft Wheat Quality Evaluation. Cereal Chemistry 63(3): 177-182.

Wheat Quality: A Quality Assessor's View. Cereal Foods World: April 1987.

Milling Quality of Eastern Soft Wheat Cultivars Grown Between 1919 and 1984. Association of Operative Millers-Bulletin-March 1988.

Predicting a Hardness Measurement Using the Single Kernel Characterization System. Cereal Chemistry 73(2): 278- 283.

Milling and Baking Qualities of Some Wheats Developed for Eastern or Northwestern Regions of the United States and Grown at Both Locations. Cereal Chemistry 73(5): 521-525

Influence of Kernel Size and Shriveling on Soft Wheat Milling and Baking Quality. Cereal Chemistry 74(6): 700-704.

Use of Aspiration and the Single Kernel Characterization System to Evaluate the Puffed and Shriveled Condition of Soft Wheat Grain. Cereal Chemistry 75(2): 207-211.

Starch-Water Relationships in the Sugar-Snap Cookie Dough System. Cereal Chemistry 75(5): 660-664.

Developing Agreement Between Very Short Flow and Longer Flow Mills. Cereal Chemistry 77(2): 187-192.

Detection of Wheat Preharvest Sprouting Using a Pregelatinized Starch Substrate and Centrifugation. Cereal Chemistry 78(3): 282-285.

Prediction of Test Weight from a Small Volume Specific Gravity Measurement. Cereal Chemistry 79(2): 227-229.

## Soft Wheat Cultivar Registrations


Chen J., E.J. Souza, N.A. Bosque-Pérez, M.J. Guttieri, K.L. O'Brien, J.M. Windes, S.O. Guy, B.D. Brown, X.M. Chen, and R.S. Zemetra (2010) Registration of 'UI Winchester' wheat. J. of Plant Registration 4: 224-227.

Chen, J. E. J. Souza, R. S. Zemetra, N. A. Bosque-Pérez, M. J. Guttieri, D. Schotzko, K. L. O'Brien, J. M. Windes, S. O. Guy, B. D. Brown, and X. M. Chen (2009) Registration of 'Cataldo' wheat. Journal of Plant Registrations 3: 264 - 268.

Griffey, C.A., W.E. Thomason, R.M. Pitman, B.R. Beahm J.J. Paling, J. Chen, J.K. Fanelli, J.S. Kenner, D.W. Dunaway, W.S. Brooks, M.E. Vaughn, E.G. Hokanson, H.D. Behl, R. A. Corbin, M.D. Hall, S. Liu, J.T. Custis, C.M. Waldenmaier, D.E. Starner, S.A. Gulick, S.R. Ashburn, D.L. Whitt, H.E. Bockelman, E.J. Souza, G.L. Brown-Guedira, J.A. Kolmer, D.L. Long, Y. Jin, X. Chen, S.E. Cambron (2010) Registration of Jamestown wheat. J. of Plant Reg. 4: 28-33.

Griffey, C.A., W.E. Thomason, R.M. Pitman, B.R. Beahm J.J. Paling, J. Chen, J.K. Fanelli, J.S. Kenner, D.W. Dunaway, W.S. Brooks, M.E. Vaughn, E.G. Hokanson, H.D. Behl, R. A. Corbin, M.D. Hall, S. Liu, J.T. Custis, C.M. Waldenmaier, D.E. Starner, S.A. Gulick, S.R. Ashburn, D.L. Whitt, H.E. Bockelman, E.J. Souza, G.L. Brown-Guedira, J.A. Kolmer, D.L. Long, Y. Jin, X. Chen, S.E. Cambron (2010) Registration of Shirley wheat. J. of Plant Reg. 4: 38-43.

Griffey, C.A., W.E. Thomason, R.M. Pitman, B.R. Beahm J.J. Paling, J. Chen, J.K. Fanelli, J.S. Kenner, D.W. Dunaway, W.S. Brooks, M.E. Vaughn, E.G. Hokanson, H.D. Behl, R. A. Corbin, M.D. Hall, S. Liu, J.T. Custis, C.M. Waldenmaier, D.E. Starner, S.A. Gulick, S.R. Ashburn, D.L. Whitt, H.E. Bockelman, E.J. Souza, G.L. Brown-Guedira, J.A. Kolmer, D.L. Long, Y. Jin, X. Chen, S.E. Cambron (2010) Registration of 3434 wheat. J. of Plant Reg. 4: 44-49.

Griffey, C.A., W. E. Thomason, R. M. Pitman, B. R. Beahm, J. J. Paling, J. Chen, P. G. Gundrum, J. K. Fanelli, D. W. Dunaway, W. S. Brooks, M. E. Vaughn, E. G. Hokanson, H. D. Behl, R. A. Corbin, J. E. Seago, B. C. Will, M. D. Hall, S. Y. Liu, J. T. Custis, D. E. Starner, S. A. Gulick, S. R. Ashburn, E. H. Jones Jr., D. L. Whitt, H. E. Bockelman, E. J. Souza, G. L. Brown-Guedira, J. A. Kolmer, D. L. Long, Y. Jin, X. Chen, and S. E. Cambron, Costa, J., H.E. Bockelman, G. Brown-Guedira, S.E. Cambron, X. Chen, A. Cooper, C. Cowger, Y. Dong, A. (2011) Registration of 'Merl' wheat. J. of Plant Registration 5: 68-74.

Griffey, C. A., W. E. Thomason, R. M. Pitman, B. R. Beahm, P. G. Gundrum, S. Y. Liu, J. Chen, J. J. Paling, D. W. Dunaway, W. S. Brooks, M. E. Vaughn, J. E. Seago, B. C. Will, E. G. Hokanson, H. D. Behl, R. A. Corbin, T. R. Lewis, M. D. Hall, J. T. Custis, D. E. Starner, S. A. Gulick, S. R. Ashburn, D. L. Whitt, H. E. Bockelman, J. P. Murphy, R. A. Navarro, E. J. Souza, G. L. Brown-Guedira, J. A. Kolmer, D. L. Long, Y. Jin, X. Chen and S. E. Cambron (2011) Registration of 'SW049029104**'** wheat**.** J. of Plant Registration 5: 91-97.

Griffey, C.A., W.E. Thomason, R.M. Pitman, B.R. Beahm J.J. Paling, J. Chen, J.K. Fanelli, J.S. Kenner, D.W. Dunaway, W.S. Brooks, M.E. Vaughn, E.G. Hokanson, H.D. Behl, R. A. Corbin, J.T. Custis, C.M. Waldenmaier, D.E. Starner, S.A. Gulick, S.R. Ashburn, D.L. Whitt, E.J. Souza, H.E. Bockelman, D.L. Long, Y. Jin, X. Chen, S.E. Cambron (2009) Registration of 'USG 3555' wheat. J. of Plant Registrations 3: 273-278.

Griffey, C.A., W.E. Thomason, R.M. Pitman, B.R. Beahm J.J. Paling, J. Chen, J.K. Fanelli, J.S. Kenner, D.W. Dunaway, W.S. Brooks, M.E. Vaughn, E.G. Hokanson, H.D. Behl, R. A. Corbin, J.T. Custis, C.M. Waldenmaier, D.E. Starner, S.A. Gulick, S.R. Ashburn, D.L. Whitt, E.J. Souza, H.E. Bockelman, D.L. Long, Y. Jin, X. Chen, S.E. Cambron (2009) Registration of '5205' wheat. J. of Plant Registrations 3: 283-288.

Grybauskas, Y. Jin, J. Kolmer, J.P. Murphy, C. Sneller, and E. Souza (2010) Registration of the soft red winter wheat germplasm MD01W233-06-1 resistant to Fusarium head blight. J. of Plant Registration 4: 255-260.

Lewis, J., L. Siler, E.Souza, P.K.W. Ng, Y. Dong, G.-L. Jiang, R.W. Ward (2010) Registration of 'Ambassador' wheat. J. of Plant Registration 4: 195-204.

Lewis, J., L. Siler, E. Souza, P.K.W. Ng, Y. Dong, G.-L. Jiang, R.W. Ward (2010) Registration of ‘Coral’ wheat. J. of Plant Registration 4: 205-214.

Lewis, J., L. Siler, E. Souza, P.K.W. Ng, Y. Dong, G. Brown-Guedira, G.-L. Jiang, R.W. Ward (2010) Registration of ‘Red Amber’ wheat. J. of Plant Registration 4: 215-223.

## Soft Wheat Proceedings

Balut, A, A, Clark, G. Brown-Guedira, E. Souza, and D. Van Sanford (2010) Validation of *Fhb1* and *Qfhs.nau-2Dl* in several SRW wheat breeding populations. National Fusarium Head Blight Forum, Milwaukee WI, Dec. 2010. Proceedings p. 127.

Cardwell, L., E. Souza, G. Brown-Guedira, Y. Dong, and J. Costa (2010) Evaluation of scab resistance and QTLs on agronomic and quality traits in soft red winter wheat. National Fusarium Head Blight Forum, Milwaukee WI, Dec. 2010. Proceedings p. 137.

Shoots, J., M. Guttieri1, F. Kolb, J. Lewis, A. McKendry, H. Ohm, C. Sneller, M.E. Sorrells, E. Souza, D. Van Sanford, J. Costa, C. Griffey, S. Harrison, J. Johnson and P. Murphy (2010) Development and distribution of male-sterile facilitated recurrent selection populations. National Fusarium Head Blight Forum, Milwaukee WI, Dec. 2010. Proceedings p. 165.

Souza, E., H. Ohm, C.A. Griffey, and A Sturbaum (2010) Milling and flour analysis of winter wheat genotypes in regional Fusarium nurseries. National Fusarium Head Blight Forum, Milwaukee WI, Dec. 2010. Proceedings p. 169.

Souza, E. (2010) Incorporating important biochemical attributes into breeding programs. Annual Meeting, Amer. Assoc. Cereal Chem. Intl. Savannah, GA. Oct. 2010. Cereal Foods World 55: A7.

Guttieri, M.J., C. Sneller, and E. Souza (2010) Distribution of non-starch polysaccharides in soft wheat pilot mill streams. Annual Meeting, Amer. Assoc. Cereal Chem. Intl. Savannah, GA. Oct. 2010. Cereal Foods World 55: A47.

Souza, E. and M.J. Guttieri (2010) Fiber variation in whole-grain soft wheat flour within the United States. Annual Meeting, Amer. Assoc. Cereal Chem. Intl. Savannah, GA. Oct. 2010. Cereal Foods World 55: A70.

Souza, E. (2010) Soft wheat and fiber. The Biscuit and Cracker Manufacturers Association Annual Technical Meeting, Birmingham AL, Oct. 2010. Webposting: http://www.thebcma.org/page_15.html.

Souza, E. (2010) Steps to a Good Soft Wheat. Sixth China Wheat Conference. Invited Presentation. Yangzhou, Jiangsu, China. March 2010. Page 9.

Kweon, M., Slade, L., Levine, H., and Souza, E. (2009) Effects of chlorination and heat treatment on flour and gluten functionality explored by solvent retention capacity (SRC) and mixograph. Proceedings of US-Japan Natural Resources Food and Agriculture Panel, Tsukuba, Japan, Oct. 2009 (Conference Proceedings).

# Regional Summaries Provided to the Wheat Industry

### Quality Characteristics of Regional Nursery Entries

Each year, wheat breeders submit elite breeding materials to cooperative yield trials known as Regional Nurseries, which are grown by other programs throughout the target production region. Grain samples from some of these nurseries are evaluated each year by the SWQL, and this information is provided to breeders in the Regional Nursery Reports as well as being posted on the SWQL website.

Narratives describing recent quality evaluations are provided below and summary tables for each are attached with this document as indicated.

**Changes in 2010 Evaluations**

We have changes for group evaluations this year. Our goal is to provide more consistent and complete information on milling and baking performance of new wheat lines and cultivars. Through a generous grant funded by the state of Ohio, the Soft Wheat Quality Laboratory has access to a new diode array NIR instrument that measures whole grain spectra. As a result we will now provide whole grain protein and grain hardness with the quality information. We also are using this instrument to develop prediction models for milling yield and softness equivalent (break flour yield). Analysis of the first two years of data, in collaboration with Mary Guttieri and Clay Sneller of Ohio State University, is promising. Prediction equations for milling yield and softness equivalent using the NIR instrument have $R^2$ values of over 75%. Our intent is to launch the use of NIR analysis for non-destructive milling yield selection within the next 18 months.

We are using multiple checks for adjusting the quality scores in the group. Previously, a single check was used for the scoring. This caused problems for a number of the evaluations due to 1) genotype x environment interactions and 2) interactions between cultivars for cookie diameters using the old sugar-snap cookie method and the revised AACC sugar-snap cookie method. Using the average of multiple checks should make the adjustments more robust. We transitioned to a new database of check cultivar performance that uses advanced milling data and cookie bakes using the revised AACC sugar-snap cookie method. The scoring system is still indirectly based on Allis mill ratings of cultivars.

The scores given in the following tables under the heading ‘advanced milling database scoring’ derive from the average milling and baking scores given in five or more millings from trials with sound grain. We transitioned to the advanced milling so that we could have more of the data based on the revised AACC sugar snap cookie data and have a broader range of check cultivars from which to choose.

Lactic acid SRC values of gluten strength will be reported on an ‘as is’ basis. We have previously corrected the lactic acid SRC values to a 9% flour protein value using the formula of 7% point increase for every 1 % point increase in flour protein. After looking at many trials across many regions, we felt that this adjustment was creating more problems than it was solving. In recent years we have had many low protein trials that have resulted in very large adjustments of lactic acid that are not realistic expectations of the genetic potential of the cultivars. We also see that some genotypes can be much more responsive than model due to the presence of 5+10 allele at the *GluD1* locus with the absence of the rye translocation on the short arm of the chromosome 1B. We can provide the lactic acid values on a protein corrected basis if requested by a researcher.

Please give us feedback on the changes in the evaluations. We are open to your suggestions for continuous improvement.

## 2010 Regional Performance and Extension Nurseries

Soft Wheat Quality Plots, Wooster OH – 2009 and 2010 Crop
SWQL Staff, USDA-ARS Wooster: 2009-2010 SWQL quality trial.xlsx

Gulf Atlantic Wheat Nursery – 2010 Crop
Stephen Harrison, Louisiana State Univ.: 2010A09 GAWN.xlsx

Mason-Dixon Regional Nursery – 2010 Crop
Carl Griffey, Virginia Polytechnical Institute: 2010A08 Mason-Dixon Regional.xlsx

Ohio Wheat Performance Trial – 2010 Crop
Richard Minyo, Ohio State University: 2010A01 Ohio Wheat Yield Trial.xlsx

Northern Uniform Winter Wheat Scab Nursery – 2010 Crop
Herb Ohm, Purdue University: 2010M02 NUWW Scab Nursery.xlsx

Southern Uniform Winter Wheat Scab Nursery – 2010 Crop
Carl Griffey, Virginia Polytechnical Institute: 2010M01 SUWW Scab Nursery.xlsx

Uniform Eastern Winter Wheat Nursery – 2010 Crop
Carl Griffey, Virginia Polytechnical Institute; Herb Ohm, Purdue University; Jose Costa, University of Maryland: 2010A05 Uniform Eastern Soft Red.xlsx

Uniform Southern Regional Soft Red Winter Wheat Nursery – 2010 Crop
S. Harrison, LSU: 2010A06 and A07 Uniform Southern Nursery.xls

Michigan State University Trial – 2010 Crop
Lee Siler, Michigan State University: 2010A11 MSU State Trials.xlsx

Uniform Eastern Soft White Winter Wheat Nursery
David Benscher, Cornell University: 2010A13 Uniform Easter Soft White.xlsx

Virginia Statewide Variety Trial – 2010 Crop
C. Griffey, Virginia Polytechnical Institute: 2010A18 Virginia Tech State Trial.xlsx

Brownstown and Urbana Variety Trial – 2010 Crop
Emerson, Nafziger; University of Illinois: 2010A16 Illinois State Variety Trial.xlsx

EXCEL DATA FILES OF EACH NURSERY ARE INCLUDED AS ATTACHMENTS TO THIS DOCUMENT AND LINKED HERE TO WEBSITE FILES.

## Gulf Atlantic Wheat Nursery – 2010 Crop

Stephen Harrison, Louisiana State University

### Advanced Milling and Baking Evaluation

A total of 75 samples were grown in a composite of nursery locations and provided to the laboratory by Stephen Harrison of LSU for milling and baking quality evaluations. The standard quality data was compared to the average for the cultivar checks given for this nursery, and quality scores for all entries are adjusted to this average. Of the 565 cultivars in the SWQL database of Allis-milled cultivars, the following table compares two checks from this trial, SS 8641 and USG 3555, with their “historical data” from the Advanced Milling databases.

These samples had no obvious signs of FHB infected kernels or pre-harvest sprouting; however, weathering was consistent within this trial before air aspiration, and it likely contributed to the evaluated lactic acid SRC and increase in softness equivalence. In general, flour yield and flour protein were within the expected target range for soft wheat characteristics, while the Sucrose SRC absorption value was above the target range. The nursery’s average (113.6%) for lactic acid SRC is considered to have “strong” gluten strength values, with GA001142-9E24 being the strongest at 145.0%. This high average is generally suitable for cracker production. Although flour analysis shows that the trial’s average softness equivalence was above normal, there were nine samples below the acceptable soft wheat quality criteria for softness equivalence, which is 50%. This indicates that they are harder than appropriate for soft wheat use; therefore, soft wheat criteria may not be appropriate for judging the quality of the samples. Test line NC07-20850 had the lowest value at softness equivalence 32.3%. This sample also had one of the highest sucrose SRC values (113.4%) and the lowest baking quality score (-22.2).

The adjusted values of the two checks are predicted to have decreased milling, baking, and softness equivalent scores when compared to the historical average of the checks. Overall, the values for flour quality measures among the checks were consistent with expectations from previous evaluations and the relative rankings of the cultivar. Therefore, we expect the results of the evaluations to be predictive of future performance of these breeding lines.

**Table 22. 2010 Gulf Atlantic Wheat Nursery**

| | | | From Advanced Milling Database Scoring | | | | Predicted from Measured Data | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lab Number | Entry Number | ENTRY | Milling Quality Score | Baking Quality Score | Softness Equivalent Score | | Milling Quality Score | | Baking Quality Score | | Softness Equivalent Score | |
| | | | | | | | | | | | | |
| 1050855 | 75 | SS8641 CK | 65.8 | 53.7 | 56.0 | | 61.8 | C | 58.4 | D | 53.5 | D |
| 1050830 | 50 | USG 3555 | 65.0 | 41.0 | 57.5 | | 60.5 | C | 40.2 | E | 53.6 | D |
| | | | | | | | | | | | | |
| | | Average | 65.4 | 47.3 | 56.8 | | 61.1 | | 49.3 | | 53.6 | |
| | | Adjustment Bias for Trial | 4.2 | -1.9 | 3.2 | | | | | | | |

**2010 Gulf Atlantic Wheat Nursery Narrative**

The Gulf Atlantic Wheat Nursery is one of the regional nurseries routinely evaluated for milling and baking quality. We are grateful to Steve Harrison for providing the samples of the nursery this year. The seed was in good shape and we expect that the results should assist you in making selection of superior quality wheat cultivars.

Milling yield is the most heritable quality trait we measure in wheat. USG 3555 is the low milling yield check in this trial. Lines with significantly less flour yield than USG 3555 (<68%) likely will be unacceptably low for flour yield in the marketplace if released as cultivars. Softness equivalent in many datasets is highly heritable when weathering is absent. Weathering tends to increase the softness of the grain as it reduces the test weight of the grain. Therefore, samples with softness equivalent scores in the 50%'s are likely coarse and are less than optimal for many cake products. NC07-20850, VA06W-146, and AR99160-4-1B have very small softness equivalent numbers and are too hard for soft wheat use.

Many of the traits evaluated in this analysis are correlated to each other, and the best quality genotypes will have favorable combinations of milling yield, softness equivalent, cookie diameter, and sucrose SRC values. Sequentially selecting the genotypes in the Gulf-Atlantic Wheat Nursery, based on those criteria and in that order, can identify the best overall genotypes in the set. Based on the sequential sorting of the lines, lines with best quality were: LA02007E227, GA021338-9E15, SCLA99049D-E1-J1, SCTX98-20-J10, SCW010025G1, SCW010025G2, andAR00036-5-1.

Genotypes with strong lactic acid values can have extra value in the manufacture of certain leavened products like crackers. Weathering often falsely elevates lactic acid SRC values, a measure of gluten strength. Likely some of the genotypes in this trial are strong gluten genotypes that may have extra value in the marketplace for the manufacture of crackers or other products requiring gluten strength. However, the samples should be assessed in another environment to confirm the gluten strength. Based on relative ranking of lactic acid, the strongest gluten genotypes with good milling yield are: LA04089D-P10, GA001142-9E23, GA001142-9E24, NC04-20417, and VA08W-286. GA001142-9E23 and GA001142-9E24 have smaller softness equivalents than normally acceptable for soft wheat use. This may be a consequence of their greater gluten strength, and they may be softer in a lower protein environment.

**Mason-Dixon Regional Nursery – 2010 Crop**
Carl Griffey, Virginia Polytechnical Institute

## Advanced Milling and Baking Evaluation

A total of 82 samples were grown in a composite of nursery locations and provided to the laboratory by Carl Griffey of Virginia Tech for milling and baking quality evaluations. The standard quality data were compared to the average for the cultivar checks given for this nursery, and quality scores for all entries are adjusted to this average. Of the 565 cultivars in the SWQL database of Allis-milled cultivars, the following table compares three checks from this trial, Pioneer 25R47, Branson, and Tribute, with their "historical data" from the Advanced Milling databases.

This trial had slight signs of FHB infected kernels but no observable weather damaged grain before air aspiration. Pre-harvest sprouting was evident in only one sample, MD03W61-09-11. Flour yield was within the expected target range for soft wheat characteristics, while flour protein, Sucrose SRC and Lactic acid SRC, a measurement of gluten strength, were above the target range. The nursery's average (118.6%) for lactic acid SRC is considered to have "strong" gluten strength values, with VA06W-146 being the strongest at 149.2%. Twenty samples were below the acceptable soft wheat quality criteria for softness equivalence, which is 50%. The harder grain and elevated lactic acid values suggest heat, moisture, or some combination of abiotic stress was present during grain filling.

The adjusted values of the three checks had decreased milling, baking, and softness equivalent scores when compared to the historical average of the checks. Overall, the values for flour quality measures among the checks were consistent with expectations from previous evaluations and the relative rankings of the cultivar. Therefore, we expect the results of the evaluations to be predictive of future performance of these breeding lines.

## Table 23. 2010 Mason-Dixon Regional Nursery

| | | | From Advanced Milling Database Scoring | | | | Predicted from Measured Data | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lab Number | Entry Number | ENTRY | Milling Quality Score | Baking Quality Score | Softness Equivalent Score | | Milling Quality Score | | Baking Quality Score | | Softness Equivalent Score | |
| 1050699 | 1 | Pioneer 25R47 | 72.8 | 94.4 | 80.4 | | 71.0 | B | 71.0 | B | 59.1 | D |
| 1050700 | 2 | Branson | 66.8 | 75.2 | 77.0 | | 60.5 | C | 57.5 | D | 69.3 | C |
| 1050702 | 4 | Tribute | 66.4 | 51.8 | 58.0 | | 63.3 | C | 48.0 | E | 45.9 | E |
| | | Average | 68.7 | 73.8 | 71.8 | | 64.9 | | 58.8 | | 58.1 | |
| | | Adjustment Bias for Trial | 3.7 | 14.9 | 13.7 | | | | | | | |

**2010 Mason-Dixon Regional Nursery Narrative**

In this trial milling yields appear to be reduced due to the stress. The cultivar checks were generally in agreement with previous evaluations. Nevertheless, cultivars with late maturity or susceptibility to abiotic stress may have smaller than expected flour yield. Tribute had a flour mill yield of 69.5%. Lines with milling yield of less than 68.0% have significantly smaller milling yield than Tribute and are normally outside the targets for commercial soft wheat cultivars. Normally, the threshold is 50% softness equivalent. In this trial the value is likely to be lower due to the stress, so lines with softness equivalent of less than 45% are probably too coarse for most applications.

Many of the traits evaluated in this analysis are correlated to each other and the best quality genotypes will have favorable combinations of milling yield, softness equivalent, cookie diameter, and sucrose SRC values. Sequentially selecting the genotypes based on those criteria, and in that order, can identify the best overall genotypes in the set. The lines with the best overall quality in the set were: KY02C-2219-04, KY03C-1136-15, MD03W61-09-11, MD02W135-08-10, VA06W-412, VA06W-44, VA07W-601, and ARS07-0607. These lines were similar to or better than Pioneer 25R47 in milling and baking quality in this trial.

The relatively large lactic acid SRC values may not be predictive of future results. However, Tribute is a strong gluten wheat, and lines with lactic acid SRC values greater than Tribute may have utility for making crackers. Lines with both good milling yield and strong gluten included: KY03C-1192-09, KY03C-1192-18, MD03W59-09-9, VA06W-146, and ARS07-0245.

# Ohio Wheat Performance Trial – 2010 Crop

Richard Minyo, Ohio State University

## Advanced Milling and Baking Evaluation

A total of 68 samples were grown by Ohio State University in Hoytville, Ohio, for milling and baking quality evaluations. The standard quality data were compared to the "historical average" for the cultivar Hopewell, and quality scores for all entries are adjusted to this average. Of the 835 cultivars in the SWQL database of Allis-milled cultivars, Hopewell ranks 715$^{th}$ for Milling Score based on data from 14 millings. The following table compares three checks, Hopewell, Roane, and Branson, with their "historical data" from the Advanced Milling databases..

This trial had obvious signs of FHB, black points, pre-harvest sprouting, and weather damaged grain before air aspiration. Grain damaged from weathering was evident in the conducted flour analysis. Flour analysis showed that there were lower than average test weights and reduced milling yields, along with an increase of softness equivalent. This trial's average (104%) for lactic acid SRC is considered to have "strong" gluten strength values, with Kenton being the strongest at 127%. Entry W 123 had the highest ranking milling quality and softness equivalence scores at 78 and 82, respectively. W 123 was also in the top six for baking quality score, which was 89. Overall, the values for flour quality measures among the check were consistent with expectations from previous evaluations and the relative rankings of the cultivar. Therefore, we expect the results of the evaluations to be predictive of future performance of these breeding lines.

**Table 24. 2010 Ohio Wheat Performance Trial**

| | | | From Advanced Milling Database Scoring | | | | | | Predicted from Measured data | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LAB NO. | ENTRY NO. | ENTRY | MILLING QUALITY SCORE | | BAKING QUALITY SCORE | | SOFT. EQUIV. SCORE | | MILLING QUALITY SCORE | | BAKING QUALITY SCORE | | SOFT. EQUIV. SCORE | |
| 1050001 | 134 | Freedom | 64.9 | C | 70.8 | B | 60.3 | C | 59.7 | D | 79.3 | B | 55.9 | D |
| 1050002 | 165 | Hopewell | 60.2 | C | 71.8 | B | 78.4 | B | 63.8 | C | 86.1 | A | 68.2 | C |
| 1050003 | 311 | Roane | 60.9 | C | 46.5 | E | 73.1 | B | 58.5 | D | 70.1 | B | 71.9 | B |
| 1050004 | 352 | Bravo | 65.0 | C | 69.0 | C | 61.2 | C | 67.1 | C | 86.0 | A | 66.5 | C |
| 1050005 | 472 | Pioneer 25R47 | 72.8 | B | 94.4 | A | 80.4 | A | 76.4 | B | 104.0 | A | 74.6 | B |
| 1050006 | 494 | Truman | 64.8 | C | 69.2 | C | 65.7 | C | 52.8 | D | 57.9 | D | 45.3 | E |
| 1050007 | 572 | Branson | 66.8 | C | 75.2 | B | 77.0 | B | 67.8 | C | 89.9 | A | 76.7 | B |
| 1050011 | 608 | AgriPro W1377 | 54.4 | D | 58.5 | D | 59.0 | D | 61.7 | C | 75.2 | B | 62.7 | C |
| 1050019 | 678 | Shirley | 68.0 | C | 80.1 | A | 67.7 | C | 66.3 | C | 96.5 | A | 66.0 | C |
| 1050027 | 716 | Malabar | 61.0 | C | 67.8 | C | 67.7 | C | 65.1 | C | 95.4 | A | 67.1 | C |
| | | | | | | | | | | | | | | |
| | | Average | 63.88 | | 70.34 | | 69.04 | | 63.91 | | 84.04 | | 65.49 | |
| | | Adjustment bias for trial | -0.03 | | -13.70 | | 3.55 | | | | | | | |

**2010 Ohio Wheat Performance Trial Narrative**

Of the characteristics of quality we measure at the Soft Wheat Quality Laboratory, milling yield is the most reproducible and, perhaps, the most important because it is genetically and environmentally associated with good soft wheat flour quality. Truman and Roane are generally considered to be poor milling yield cultivars. Other lines with similar flour yield in 2010 were Sunburst and Beck 113. Within this trial, based on comparisons to known check cultivars, lines with milling yields above 69.5% would generally be acceptable for most commercial applications, and lines with milling yield above 71.0% would be excellent for milling yield. The second most important quality trait is softness equivalent as it measures the ease of milling and the particle size of the flour. Larger values are preferred, particularly for cake flour. All the cultivars in this trial are acceptable for softness equivalent, and cultivars with softness equivalent values above 57% are desirable for quality, if the milling yield is acceptable. For the other quality measures, smaller values are desirable for grain hardness, water solvent retention capacity (SRC), sodium carbonate SRC, and sucrose SRC. Larger values are desirable for cookie diameters. Lactic acid SRC is a measure of gluten strength. Lactic acid SRC values within this trial should be in a range from 90% to 115% for most products, based on comparisons to the lactic acid SRC values of known check cultivars. Cultivars with lactic acid values greater than 115% may have some additional value for crackers or other leavened foods.

When considering quality please make comparisons back to information on Fusarium head blight resistance provided by the Ohio State University with the yield information of this trial. Most flour millers consider Fusarium head blight resistance as an essential component of milling and baking quality. Resistant cultivars planted and managed with appropriate timely application of a fungicide registered for the control of Fusarium head blight will reduce the incidence of the disease significantly. This is true even in a year such as 2010 with heavy disease pressure.

## Northern Uniform Winter Wheat Scab Nursery – 2010 Crop

Herb Ohm, Purdue University

### Micro Milling and Baking Evaluation

A total of 59 samples were grown in Lafayette, Indiana, and graciously provided by Herb Ohm of Purdue University for milling and baking quality evaluations. The standard quality data was compared to the average for the cultivar checks given for this nursery, and quality scores for all entries are adjusted to this average. Of the 565 cultivars in the SWQL database of Allis-milled cultivars, the following table compares three checks from this trial, Ernie, Truman, and Freedom, with their "historical data" from the Micro Milling databases.

This nursery had a significant number of samples that contained both FHB infected and weather damaged seed. Pre-harvest sprouting was noticeably present, especially within the sample 99691A2-5-4-16-1. Grain moisture was 13.9%. Flour analysis average for this nursery demonstrates that flour yield and sucrose SRC were below the expected target range for soft wheat characteristics, while softness equivalence was above the target range. Based on milling analysis, a total of seven samples are likely hard wheat genotypes, with a softness equivalence of less than 50%. A combination of low sucrose SRC and flour protein typically produces a larger cookie diameter and higher baking scores, which is evident with test lines E3024 and IL06-7550 as they rank 1 and 2 for baking quality. In general, the three checks have lower than expected quality scores based from their historical data. Therefore, we expect the results of the evaluations to be generally predictive of future performance of breeding lines in this trial.

The evaluation scores sheet in the MS Excel file includes the average field ratings for Fusarium resistance from cooperators. The values were distributed by Clay Sneller. We have used the average Fusarium index (index) and the average Fusarium damaged kernel (FDK) scores as indicators of resistance. Larger values for the index and FDK scores indicate greater susceptibility to Fusarium.

**Table 25. 2010 Northern Uniform Winter Wheat Scab Nursery**

| | | | From Advanced Milling Database Scoring | | | | Predicted from Measured Data | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lab Number | Entry Number | ENTRY | Milling Quality Score | Baking Quality Score | Softness Equivalent Score | | Milling Quality Score | | Baking Quality Score | | Softness Equivalent Score | |
| | | | | | | | | | | | | |
| 1010073 | 189 | ERNIE | 63.0 | 61.1 | 65.6 | | 60.3 | C | 68.4 | C | 63.6 | C |
| 1010074 | 190 | TRUMAN | 64.8 | 69.2 | 65.7 | | 56.8 | D | 62.3 | C | 68.5 | C |
| 1010075 | 191 | FREEDOM | 64.9 | 70.8 | 60.3 | | 55.3 | D | 70.5 | B | 60.8 | C |
| | | | | | | | | | | | | |
| | | Average | 64.22 | 67.07 | 63.85 | | 57.46 | | 67.05 | | 64.29 | |
| | | Adjustment Bias for Trial | 6.75 | 0.02 | -0.44 | | | | | | | |

**2010 Northern Uniform Winter Wheat Scab Nursery Narrative**

The Northern Uniform Winter Wheat Scab Nursery routinely screens hard wheat cultivars. Our testing protocols are not appropriate for hard wheat testing. The lactic acid values may give some indication of relative gluten strength but other evaluations should not be used for comparisons to soft wheat lines. GS-0-EM0681, GS-0-EM0614, GS-1-EM0362, WESLEY, WESLEYFHB1, NE06607, NE06469, and NW07505 had milling profiles similar to Wesley and other hard wheat genotypes. These lines will not be discussed further.

Flour yield is generally the most heritable quality trait we evaluate. The average flour yield for this location was low due to the poor condition of the seed. Yet the relative rankings of the genotypes should be fairly predictive of future performance. Lines with flour yields significantly below Truman may have unacceptably low flour yield. Truman had a flour yield of 68%; lines with flour yields of 66.5% are likely to have poor milling yield if released as cultivars.

Sequentially selecting for flour yield, softness equivalent and sucrose SRC should identify the best quality genotypes in this study. Among the lines with better than average ratings for both Fusarium index and FDK, the best quality lines were: 03M1539#031, IL06-7550, IL06-14262, and MO071522.

**Southern Uniform Winter Wheat Scab Nursery – 2010 Crop**

Carl Griffey, Virginia Polytechnical Institute

## Micro Milling and Baking Evaluation

A total of 58 samples were grown in Warsaw, Virginia, and submitted by Carl Griffey of Virginia Tech for milling and baking quality evaluations. The standard quality data were compared to the average for the cultivar checks given for this nursery, and quality scores for all entries are adjusted to this average. Of the 565 cultivars in the SWQL database of Allis-milled cultivars, the following table compares four checks from this trial, Ernie, Coker 9835, Bess, and Jamestown, with their “historical data” from the Micro Milling databases.

This trial did not have any physical observable evidence of FHB infection, weather damage, pre-harvest sprouting concerns, or black point seed before air aspiration. Flour analysis average for this nursery demonstrates that flour yield and sucrose SRC were below the expected target ranges for soft wheat characteristics, while softness equivalence and flour protein were above the target ranges. Flour analysis concludes that there are a total of ten samples that are below the acceptable soft wheat quality criteria for softness equivalence, which is 50%. This implies that they may be poorly adapted for soft wheat, and our normal soft wheat evaluations may not be appropriate to judge the quality of the lines. Over 40% of the samples (23 of 58) were relatively “strong” gluten lines (lactic acid greater than 105%) indicating that the location and the germplasm were greater than average for gluten strength. The largest value for the lactic acid gluten strength measure was is ARS03-4736 at 123.9%. The check Ernie had milling and baking scores below previous measurements, relative to the other check cultivars. Even though Bess had a low baking score, its predicted milling quality was highest amongst the checks. The other check cultivars, Coker 9835 and Jamestown, were consistent with their expected performance. Therefore, we expect the results of the evaluations to be generally predictive of future performance of breeding lines in this trial.

**Table 26. 2010 Southern Uniform Winter Wheat Scab Nursery**

| | | | From Advanced Milling Database Scoring | | | Predicted from Measured Data | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Lab Number | Entry Number | ENTRY | Milling Quality Score | Baking Quality Score | Softness Equivalent Score | Milling Quality Score | | Baking Quality Score | | Softness Equivalent Score | |
| | | | | | | | | | | | |
| 1010001 | 1 | ERNIE | 63.0 | 61.1 | 65.6 | 52.0 | D | 40.0 | F | 59.0 | D |
| 1010002 | 2 | COKER 9835 | 68.7 | 61.1 | 85.1 | 60.1 | C | 53.3 | D | 78.7 | B |
| 1010003 | 3 | BESS | 56.2 | 64.0 | 57.5 | 62.1 | C | 49.6 | E | 64.7 | C |
| 1010004 | 4 | JAMESTOWN | 59.9 | 43.1 | 61.0 | 58.0 | D | 40.7 | E | 62.5 | C |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | Average | 61.92 | 57.33 | 67.31 | 58.04 | | 45.89 | | 66.22 | |
| | | Adjustment Bias for Trial | 3.87 | 11.44 | 1.09 | | | | | | |

**2010 Southern Uniform Winter Wheat Scab Nursery Narrative**

Thank you to Carl Griffey for producing the trial and shipping us the seed. This evaluation would not be possible without his collaboration. Flour yield is generally the most heritable quality trait we evaluate. The average flour yield for this location was low due to the poor condition of the seed. Yet the relative rankings of the genotypes should be fairly predictive of future performance. Lines with flour yields significantly below Ernie may have unacceptably low flour yield. Ernie had a flour yield 67%; lines with flour yields of 67% or less are likely to have poor milling yields if released as cultivars.

Sequentially selecting for flour yield, softness equivalent and sucrose SRC should identify the best quality genotypes in this study. Among the lines with both Fusarium damaged kernels (FDK) and Deoxynivalenol (DON) levels within an $LSD_{0.05\%}$ of the best entry in each category, the best quality lines were: MD01W233-07-1, AR99264-8-1, VA08W-622, and M08*8005#.

The relatively large lactic acid SRC values may not be predictive of future results as the whole location seems to be a relatively strong gluten location and we do not have a strong gluten check against which we can benchmark. Lines with both good Fusarium resistance and strong gluten included: VA09W-641, NC07-24445, ARS04-1267, and LA02058E97.

Novel genes for resistance that are marked as QTL often appear to have linkage drag with undesirable milling and baking quality. After cycles of inter-mating the linkage disequilibrium is likely minimal, yet we feel it is important to identify for crossing cycles the breeding lines carrying known QTL for FHB resistance that also excel for milling and baking quality. Among the three lines carrying the 3BS QTL, LA01164D-94-2 has the best soft wheat quality. LA03186E2 has the best quality of the lines carrying the Wuhan-1 2DL QTL. Few of the lines with the 3BSc had good quality, but the best was NC07-24445. Similarly, the best quality line of those carrying the 5AS resistance QTL was W1104.

# Uniform Eastern Winter Wheat Nursery – 2010 Crop

Carl Griffey, Virginia Polytechnical Institute; Herb Ohm, Purdue University;
Jose Costa, University of Maryland

## Advanced Milling and Baking Evaluation

A total of 46 samples were grown in a composite of nursery locations and were submitted by Virginia Tech, Purdue University and University of Maryland for milling and baking quality evaluations. The standard quality data were compared to the average for the cultivar checks given for this nursery, and quality scores for all entries are adjusted to this average. Of the 565 cultivars in the SWQL database of Allis-milled cultivars, the following table compares four checks from this trial, INW0411, Branson, Bess and Shirley, with their “historical data” from the Advanced Milling databases.

This trial had slight signs of FHB infected and weather damaged grain before air aspiration. Pre-harvest sprouting was evident in only one sample, KY00C-2567-01, and may have a direct effect on its lactic acid SRC value at 122.1%, the highest out of 46 samples. Flour analysis of this nursery showed that flour protein, flour yield, water SRC, and lactic acid SRC, a measurement of gluten strength, were within the expected target ranges for soft wheat characteristics. Sucrose SRC was below, while sodium carbonate SRC was above the target range. Test line NX05M4180-6 is full waxy (100% amylopectin) genotype. All values for this wheat are out of specifications for a soft wheat, despite having a soft endosperm. INW0411 had milling yields below previous measurements, relative to the other check cultivars. Shirley’s baking performance also was below its normal performance due to coarser flour than normal (smaller softness equivalent). The other check cultivars were consistent with their expected performance. Therefore, we expect the results of the evaluations to be generally predictive of future performance of breeding lines in this trial.

# Table 27. 2010 Uniform Eastern Winter Wheat Nursery

| | | | From Advanced Milling Database Scoring | | | | | | Predicted from Measured data | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lab Number | Entry Number | ENTRY | Milling Quality Score | | Baking Quality Score | | Softness Equivalent Score | | Milling Quality Score | | Baking Quality Score | | Softness Equivalent Score | |
| | | | | | | | | | | | | | | |
| 1050561 | 1 | INW0411 | 66.0 | | 57.2 | | 63.9 | | 60.9 | C | 67.1 | C | 57.9 | D |
| 1050562 | 2 | Branson | 66.8 | | 75.2 | | 77.0 | | 71.3 | B | 84.9 | A | 70.2 | B |
| 1050563 | 3 | Bess | 56.2 | | 64.0 | | 57.5 | | 60.6 | C | 82.8 | A | 61.6 | C |
| 1050564 | 4 | Shirley | 68.0 | | 80.1 | | 67.7 | | 65.9 | C | 77.9 | B | 60.6 | C |
| | | | | | | | | | | | | | | |
| | | Average | 65.56 | | 65.86 | | 63.86 | | 65.64 | | 75.85 | | 61.70 | |
| | | Adjustment bias for trial | -0.07 | | -9.99 | | 2.16 | | | | | | | |

**2010 Uniform Eastern Winter Wheat Nursery Narrative**

The Uniform Eastern Soft Red Winter Wheat Nursery represents one of the last stages of testing by wheat breeding programs before release of a breeding line as a new cultivar. In this trial, a composite of grain samples from Virginia Tech, Purdue University and University of Maryland is representative of the region. Samples were evaluated for milling and baking quality using methods approved by the American Association of Cereal Chemists.

Flour yield commonly is the most heritable trait evaluated by the SWQL. In this nursery, Bess had a flour yield of 68.9%. Breeding lines with flour yield similar to or less than Bess may have poor milling quality. Lines with flour yield more than a percentage point less than Bess likely are unacceptable for commercial milling. The second most heritable trait evaluated by the SWQL is softness equivalent. Softness equivalent is a predictor of break flour yield. It also is a measure of flour particle size, as it is estimated as the percent of break flour passing through a standard 94 mesh screen. Larger values are preferred for most soft wheat products, particularly cakes and other high sugar baked products. All of the breeding lines in the nursery were true soft genotypes as graded by the softness equivalent.

Selecting sequentially for the following traits of greater flour yield, greater softness equivalent, larger cookie diameters, and smaller values of sodium carbonate SRC identifies the following lines: W06-089, AR98023-5-1, B170, MO 050921, Z03-3352, XY04-37, IL04-24668, and G89263. These are the best quality soft wheat lines in the nursery for general use in the widest range of soft wheat products. They have value both as potential cultivars but also as breeding parents for subsequent improvement of the soft winter wheat germplasm pool.

Lactic acid SRC is a measure of the strength of the native glutenin macro-polymer in flour. Although many soft wheat products do not require excess gluten strength, most commercial food production requires some gluten strength. Therefore, very weak gluten strength lines (below 85% in this evaluation) will cause problems for the manufacturers if they dominated the grain production of a region. Most soft wheat cultivars are in a middle range similar to Branson or slightly greater for gluten strength. A few genotypes in this trial were exceptionally strong for glutenin, as measured by lactic acid SRC. The strongest of these were MD02W135-08-9, B169, and MO 080104. These lines may have added value for the production of crackers, due to the extra gluten strength.

**Uniform Southern Regional Soft Red Winter Wheat Nursery – 2010 Crop**

Stephen Harrison, Louisiana State University

## Advanced Milling and Baking Evaluation

For the Uniform Southern Interior evaluation, a total of 32 samples of the Uniform Southern Soft Red Winter Wheat Nursery were submitted for milling and baking quality evaluations from five locations: Bay, AR, Warsaw, VA, Belle Mina, AL, Knoxville, TN, Queenstown, MD. The standard quality data were compared to the average for the cultivar checks given for this nursery, and quality scores for all entries are adjusted to this average. Of the 565 cultivars in the SWQL database of Allis-milled cultivars, the following table compares four checks from this trial, AGS 2000, Pioneer 26R61, Coker 9553, and USG 3555, with their "historical data" from the Advanced Milling databases.

This interior trial had slight signs of FHB infected and weather damaged grain before air aspiration, but pre-harvest sprouting was not obviously present. Flour protein and flour yield were within the expected target range for soft wheat characteristics, while sucrose SRC and lactic acid SRC were greater than normal. Sixteen samples had "strong" gluten lactic acid values, with LA01056D-84-7-2 being the strongest. A strong gluten strength value above 110% is generally appropriate for cracker production. Test line B05-0329 had the highest flour yield (74.2%) within this nursery and was in the top three for cookie diameter (19.2 cm). Flour analysis also concludes that the four checks are predicted to have an increase in softness equivalence when compared to the historical average of the checks. Overall, the values for flour quality measures among the checks were consistent with expectations from previous evaluations and the relative rankings of the cultivar. Therefore, we expect the results of the evaluations to be predictive of future performance of these breeding lines.

Three coastal locations, Blacksburg, VA, Newton, MS, Plains, GA, were submitted for milling and baking quality evaluations for the Coastal Composite. The samples were composited and compared using the four checks, AGS 2000, Pioneer 26R61, Coker 9553, and USG 3555.

This Coastal Composite trial had slight signs of FHB infected and weather damaged grain before air aspiration, but pre-harvest sprouting was not obviously present. Flour protein and flour yield were within the expected target range for soft wheat characteristics, while sucrose SRC and lactic acid SRC, a measurement of gluten strength, were above the target ranges. .

## Table 28. 2010 Uniform Southern Soft Red Winter Wheat Nursery – Interior

| | | | From Advanced Milling Database Scoring | | | | Predicted from Measured Data | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lab Number | Entry Number | ENTRY | Milling Quality Score | Baking Quality Score | Softness Equivalent Score | | Milling Quality Score | | Baking Quality Score | | Softness Equivalent Score | |
| 1050621 | 1 | AGS 2000 | 81.5 | 62.3 | 67.2 | | 77.8 | B | 64.4 | C | 76.4 | B |
| 1050622 | 2 | Pioneer Brand 26R61 | 68.9 | 51.8 | 60.9 | | 66.4 | C | 49.8 | E | 65.5 | C |
| 1050623 | 3 | Coker 9553 | 61.4 | 47.9 | 66.2 | | 64.2 | C | 52.2 | D | 71.5 | B |
| 1050624 | 4 | USG 3555 | 65.0 | 41.0 | 57.5 | | 62.1 | C | 44.5 | E | 67.4 | C |
| | | Average | 69.2 | 50.7 | 63.0 | | 67.6 | | 52.7 | | 70.2 | |
| | | Adjustment Bias for Trial | 1.6 | -2.0 | -7.2 | | | | | | | |

**Table 29. 2010 Uniform Southern Soft Red Winter Wheat Nursery – Coastal**

| | | | From Advanced Milling Database Scoring | | | | Predicted from Measured Data | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lab Number | Entry Number | ENTRY | Milling Quality Score | Baking Quality Score | Softness Equivalent Score | | Milling Quality Score | | Baking Quality Score | | Softness Equivalent Score | |
| | | | | | | | | | | | | |
| 1050654 | 1 | AGS 2000 | 81.5 | 62.3 | 67.2 | | 70.0 | C | 55.0 | D | 60.6 | C |
| 1050655 | 2 | Pioneer Brand 26R61 | 68.9 | 51.8 | 60.9 | | 59.8 | D | 46.6 | E | 51.9 | D |
| 1050656 | 3 | Coker 9553 | 61.4 | 47.9 | 66.2 | | 57.0 | D | 41.4 | E | 62.4 | C |
| 1050657 | 4 | USG 3555 | 65.0 | 41.0 | 57.5 | | 57.3 | D | 36.5 | F | 53.5 | D |
| | | | | | | | | | | | | |
| | | Average | 69.2 | 50.7 | 63.0 | | 61.0 | | 44.9 | | 57.1 | |
| | | Adjustment Bias for Trial | 8.2 | 5.9 | 5.9 | | | | | | | |

**2010 Uniform Southern Regional Soft Red Winter Wheat Nursery Narrative**

The Uniform Southern Nursery is an important evaluation of breeding materials that will be released as cultivars, used in crossing for future cultivars, and as a dataset collectively for future genetic studies. The two regional composites were similar in their appearance, with general absence of grain defects such as sprouting or severe weathering.

My comments will be directed primarily to the average of the two composite represented in the summary file included with the reports for the individual composites. Significant genotype variation was observed for all of the quality attributes. The largest genetic variance based on F-test values were for milling yield and lactic acid SRC. The smallest F-values for genotypic effects were for grain protein and top-grade score for cookies.

Among the checks, USG 3555 is a low flour yield check. Only two lines, VA05W-139 and NC06-20401 were significantly below USG 3555 for flour yield. Softness equivalent in many datasets is highly heritable when weathering is absent. All the lines were, on average, within the range expected for softness equivalent. Yet, in locations with harder, stressed grain, lines with low softness equivalent will mill poorly and produce low break flour yield and high damaged starch levels in the flour. Selection for greater values of softness equivalent will improve the overall quality of the wheat produced in the eastern US.

Many of the traits evaluated in this analysis are correlated to each other, and the best quality genotypes will have favorable combinations of milling yield, softness equivalent, cookie diameter, and sucrose SRC values. Sequentially selecting the genotypes in the Uniform Southern Nursery, based on those criteria and in that order, we identified the best overall genotypes in the set. Lines with quality similar to or better than AGS 2000 were: VA06W-392, LA01139D-56-1, B05-0142, LA01139D-86-2, and G75692.

Genotypes with strong lactic acid values can have extra value in the manufacture of certain leavened products like crackers. Lines that have both good milling characteristics and large lactic acid SRC values included: AR96052-4-3, NC05-19684, MD00W389-08-4, B05-0142. These lines may have added value for food manufacturers. Two lines had very strong gluten strength but poor milling characteristics: LA01056D-84-7-2 and VA05W-139. These lines may have value as breeding parents for the development of future strong gluten wheat lines.

**Michigan State University Trial – 2010 Crop**

Lee Siler, Michigan State University

## Advanced Milling and Baking Evaluation

A total of 111 samples were grown for a quality study and then were submitted by Lee Siler of Michigan State University for milling and baking quality evaluations. The standard quality data were compared to the average for the cultivar checks given for this nursery, and quality scores for all entries are adjusted to this average. Of the 565 cultivars in the SWQL database of Allis-milled cultivars, the following table compares five checks from this trial: , Ambassador, Aubrey, Caledonia, D8006, and Pioneer 25R47, with their “historical data” from the Advanced Milling databases.

This study had sparse signs of FHB infected grain and no visible evidence of pre-harvest sprouting concerns. Weather damaged grain was present before air aspiration. Our flour analyses found that flour yield and sodium carbonate SRC were within the expected target ranges for soft wheat characteristics. Flour protein, lactic acid and sucrose SRC were below the normal ranges, while the softness equivalence and water SRC were above the ranges we observe for these cultivars.

Even though flour analysis shows that the trial’s average for sodium carbonate is within cookie baking range (less than 68%), test line Sunburst has a possibility of damaged starch present due to its high percentage score, which is 73.9%. Sunburst also has the highest water SRC value at 59.1% and lowest milling yield at 65.1% within the trial. Test line Milton had the highest milling yield out of all the samples at 74.3%. Analysis also concludes that MSU Line E9003 was the only sample that scored an “E” on the softness equivalence, and it may be considered a hard wheat because it was below the acceptable soft wheat quality criteria for softness equivalence, which is 50%. The nursery’s average for lactic acid SRC is considered to have “weak” gluten strength values (lactic acid below 85%), with the test line MSU Line E9047 having the lowest at 61.0%.

The adjusted values of the five checks are predicted to have an increase in milling and baking scores, but a reduced softness equivalent score when compared to the historical average of the checks. Overall, the values for flour quality measures among the checks were consistent with expectations from previous evaluations and the relative rankings of the cultivar. Therefore, we expect the results of the evaluations to be predictive of future performance of these breeding lines.

## Table 30. 2010 Michigan State University Trial

| | | | From Advanced Milling Database Scoring | | | Predicted from Measured Data | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | ENTRY | Milling Quality Score | Baking Quality Score | Softness Equivalent Score | Milling Quality Score | | Baking Quality Score | | Softness Equivalent Score | |
| | | | | | | | | | | | |
| Average of 2 Checks | | Ambassador | 71.8 | 93.5 | 69.9 | 72.7 | B | 108.3 | A | 69.0 | C |
| Average of 2 Checks | | Aubrey | 62.2 | 77.0 | 75.1 | 69.5 | C | 91.7 | A | 74.4 | B |
| Average of 2 Checks | | Caledonia | 69.8 | 90.2 | 69.5 | 72.0 | B | 105.3 | A | 68.6 | C |
| Average of 2 Checks | | D8006 | 70.8 | 92.1 | 75.6 | 79.5 | B | 106.0 | A | 73.4 | B |
| Average of 2 Checks | | Pioneer 25R47 | 72.8 | 94.4 | 80.4 | 71.1 | B | 112.3 | A | 74.2 | B |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | Average | 69.5 | 89.4 | 74.1 | 73.0 | | 104.7 | | 71.9 | |
| | | Adjustment Bias for Trial | -3.5 | -15.3 | 2.2 | | | | | | |

**2010 Michigan State University Trial Narrative**

Roane is typically considered a threshold cultivar, that is, new cultivars should have greater milling yields than Roane. The experimental lines MSU Line E9003, MSU Line E9012R, and MSU Line E9029 were similar to Roane for milling yield and would likely be poor milling cultivars if released.

All the cultivars in this trial would be considered soft wheat genotypes based on the softness equivalent measure. As noted above E9003 is pretty hard for a soft wheat. The overall softness equivalent value of the trial is greater than normal so the cutoff threshold should probably be raised. Sunburst is typically too hard of a wheat and its softness equivalent value is 56%. Softness equivalent measures the percentage of flour from the Quad Jr that can pass through a fine (94 mesh) screen. Therefore MSU Line E9012R, MSU Line E9029, and MSU Line E9052 may be too coarse under most conditions to produce the best quality cake flours.

Many of the traits evaluated in this analysis are correlated to each other, and the best quality genotypes will have favorable combinations of milling yield, softness equivalent, cookie diameter, and sucrose SRC values. Sequentially selecting lines based on these characteristics should select the best quality wheat lines. In this trial the best quality experimental lines were: MSU Line E5011, MSU Line E9019R, MSU Line E9042, MSU Line E9046, MSU Line E9049, and MSU Line E9060. These lines were similar in quality to D8006. With the exception of MSU Line E9049, all of these lines also are weak gluten. They may cause problems for some millers.

Due to the low protein levels of the group the overall gluten strength of the trial was relatively weak. D8006 is a moderately strong gluten wheat, but not exceptionally strong. The lines with significantly stronger gluten than D8006 were MSU Line E8052, MSU Line E9019R, MSU Line E9020R, MSU Line E9021R, and MSU Line E9022R. It may have added value for use in the manufacture of whole grain products and crackers.

**Uniform Eastern Soft White Winter Wheat Nursery – 2010 Crop**
David Benscher, Cornell University

## Advanced Milling and Baking Evaluation

A total of 25 samples were grown in a composite of nursery locations and provided to the laboratory by David Benscher of Cornell University for milling and baking quality evaluations. The standard quality data were compared to the average for the cultivar checks given for this nursery, and quality scores for all entries are adjusted to this average. Of the 565 cultivars in the SWQL database of Allis-milled cultivars, the following table compares three checks from this trial, Augusta, Cayuga, and Jensen, with their "historical data" from the Advanced Milling databases.

These nursery samples showed very little signs of FHB infected kernels with no visible evidence of pre-harvest sprouting concerns. However, weathering was observed throughout the whole nursery before air aspiration. In general, flour analysis provided results that illustrated an increase in flour yield and softness equivalence, whereas flour protein, sucrose SRC, and lactic acid SRC were within the expected target range for soft wheat characteristics.

Although lactic acid SRC, a measurement of gluten strength, was found to be in the target range, test line E2041 had the makeup of having a "strong" gluten strength value (lactic acid above 105%) and may be more suitable for cracker production. This entry also had the highest sucrose SRC absorption value at 104.4%, and it positioned near the bottom of baking quality score at 47.7. Milling yield is an important factor in evaluating this nursery, and test line W1062 had the highest yield at 73.5%. W062 also had the lowest sucrose SRC value at 85.4%. Further analysis concludes that sample SE00 10277-12 is possibly better suited for a cookie bake as evident in the data. A good cookie quality consists of large values for milling yield and softness equivalence with low sucrose SRC. SE00 10277-12 fits this trend as it consistently ranks highly with those three criteria for this sample set.

The adjusted values of the checks, Augusta and Jensen, are predicted to have an increase in milling, baking, and softness equivalent scores, while Cayuga is expecting to increase only in the baking score when compared to the historical average of the three checks. Overall, the values for flour quality measures among the checks were consistent with expectations from previous evaluations and the relative rankings of the cultivar. Therefore, we expect the results of the evaluations to be predictive of future performance of these breeding lines.

## Table 31. 2010 Uniform Eastern Soft White Winter Wheat Nursery

| | | | From Advanced Milling Database Scoring | | | | Predicted from Measured Data | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lab Number | Entry Number | ENTRY | Milling Quality Score | Baking Quality Score | Softness Equivalent Score | | Milling Quality Score | | Baking Quality Score | | Softness Equivalent Score | |
| | | | | | | | | | | | | |
| 1051142 | 1507 | Augusta | 69.6 | 83.6 | 70.4 | | 70.5 | B | 91.0 | A | 70.9 | B |
| 1051150 | 1515 | Cayuga | 65.1 | 57.6 | 78.5 | | 62.2 | C | 73.9 | B | 72.8 | B |
| 1051160 | 1525 | Jensen (NY88046-8138) | 69.1 | 79.6 | 69.7 | | 70.0 | C | 83.6 | A | 72.3 | B |
| | | | | | | | | | | | | |
| | | Average | 68.0 | 73.6 | 72.9 | | 67.6 | | 82.8 | | 72.0 | |
| | | Adjustment Bias for Trial | 0.4 | -9.2 | 0.9 | | | | | | | |

**2010 Uniform Eastern Soft White Winter Wheat Nursery Narrative**

As in past years, all samples in the trial had acceptable milling quality. Cayuga, a cultivar with acceptable quality, had the smallest milling yield. All other lines had larger milling yield than Cayuga. Similarly all lines were soft milling based on the softness equivalent score. We use 50% as a cut-off for acceptable softness equivalent. All lines had much greater softness equivalent than 50% and were therefore acceptable for a broad range of soft wheat products.

To select the best lines for milling and baking quality, we sequentially sorted for flour yield and selected all lines with greater flour yield than the nursery average. We then sorted among those selected lines for softness equivalent and again selected lines with values greater than the nursery average. Finally, we sorted for cookie diameter, and the following lines had cookie diameters greater than the nursery average: Cal 4PHS-10, TW435*025, NY03180FHB-10, E3024, and NY103-208-7263. These lines were similar or better in milling and baking quality than Augusta and Superior.

As noted above, E2041 had much greater gluten strength than the checks. E6045 and RCDH-19/21 also had large lactic acid values. Typically, as lactic acid SRC values increase, so do sucrose SRC values. The sucrose SRC preferentially hydrates arabinoxylans but also swells the gliadins of the flour. E2041 and E6045 both had good cookie evaluations suggesting that the elevated sucrose values in those wheats were likely due to gliadins and would be acceptable for most soft wheat products that require strong gluten.

**Virginia Statewide Variety Trial – 2010 Crop**
Carl Griffey, Virginia Polytechnical Institute

### Advanced Milling and Baking Evaluation

A total of 40 samples were grown for a quality study in Virginia and submitted by Carl Griffey of Virginia Tech for milling and baking quality evaluations. The standard quality data were compared to the average for the cultivar checks given for this nursery, and quality scores for all entries are adjusted to this average. Of the 261 cultivars in the SWQL database of Advanced Mill Database cultivars, the following table compares 12 checks from this trial, Massey, Jamestown, SS 5205, Pioneer 26R15, SS-MPV 57, Chesapeake, USG 3555, Shirley, Renwood 3434, USG 3665, Coker 9553, and Branson, with their “historical data” from the Advanced Milling databases.

This study showed some signs of weathering, black point affected grain before air aspiration. After air aspiration, shriveling of the grain was present, and was likely related to heat stress. Our flour analyses, when compared to the historical data of the given checks, found that the total flour extraction was similar to historical levels but baking quality and, even more so, softness equivalent was less than expected based on historical values. This indicates that the trial likely had sufficient stress to increase the hardness of the kernels. The observed scores for the 12 checks correlated to the historical scores at a level of r>0.8, indicating that the results of this trial are likely predictive of future results.

## Table 32. 2010 Virginia Statewide Variety Trial

| | | | From Advanced Milling Database Scoring | | | | | | | Predicted from Measured Data | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lab Number | Entry Number | ENTRY | Milling Quality Score | | Baking Quality Score | | Softness Equivalent Score | | | Milling Quality Score | | Baking Quality Score | | Softness Equivalent Score | |
| 1051521 | AQL-1 | MASSEY | 74.7 | B | 45.6 | E | 68.5 | C | | 74.5 | B | 39.4 | F | 57.8 | D |
| 1051522 | AQL-2 | JAMESTOWN | 60.1 | C | 31.3 | F | 62.2 | C | | 63.1 | C | 25.6 | F | 59.7 | D |
| 1051538 | AQL-18 | SS 5205 | 68.1 | C | 73.5 | B | 78.8 | B | | 68.8 | C | 62.8 | C | 65.4 | C |
| 1051539 | AQL-19 | Pioneer 26R15 | 69.8 | C | 52.0 | D | 76.1 | B | | 69.2 | C | 57.1 | D | 61.5 | C |
| 1051542 | AQL-22 | SS-MPV 57 | 72.9 | B | 47.4 | E | 58.3 | D | | 71.4 | B | 44.9 | E | 42.2 | E |
| 1051544 | AQL-24 | CHESAPEAKE | 62.1 | C | 46.0 | E | 63.6 | C | | 62.8 | C | 43.5 | E | 46.3 | E |
| 1051545 | AQL-25 | USG 3555 | 62.7 | C | 37.2 | F | 58.2 | D | | 58.7 | D | 26.8 | F | 46.5 | E |
| 1051546 | AQL-26 | SHIRLEY | 67.4 | C | 66.7 | C | 67.5 | C | | 69.9 | C | 51.2 | D | 49.9 | E |
| 1051547 | AQL-27 | Renwood 3434 | 62.8 | C | 65.6 | C | 69.5 | C | | 61.1 | C | 66.0 | C | 61.3 | C |
| 1051548 | AQL-28 | USG 3665 | 72.6 | B | 52.9 | D | 70.9 | B | | 70.6 | B | 65.9 | C | 57.5 | D |
| 1051549 | AQL-29 | COKER 9553 | 61.5 | C | 43.2 | E | 65.6 | C | | 59.2 | D | 47.2 | E | 51.5 | D |
| 1051550 | AQL-30 | Branson | 66.9 | C | 64.6 | C | 76.6 | B | | 66.1 | C | 61.4 | C | 65.8 | C |
| | | Average | 66.8 | | 52.2 | | 68.0 | | | 66.3 | | 49.3 | | 55.4 | |
| | | Adjustment Bias for Trial | 0.5 | | 2.9 | | 12.5 | | | | | | | | |

**2010 Virginia Statewide Variety Trial Narrative**

Milling yield is the first criteria for selection of cultivars. The average milling yield of the 12 checks was 70.1. Lines more than 2 standard errors (~2% points) below the average are likely significantly below the average for milling yield. VA08W-92 has the smallest flour yield at 68.3 which is close to this threshold, and it is likely similar to USG 3555. All the other breeding lines have greater flour extraction. The next most heritable trait in the quality evaluations is softness equivalent. Several of the check lines had softness equivalents in the range of hard wheats. They normally would be above 50% but are much harder due to the environmental conditions. VA08W-92 also had a poor softness equivalent--a sign that this line may not have commercial application as a cultivar.

Many of the traits evaluated in this analysis are correlated to each other, and the best quality genotypes will have favorable combinations of milling yield, softness equivalent, cookie diameter, and sucrose SRC values. Sequentially selecting the genotypes in the nursery should identify the lines with the best soft wheat quality. Using these criteria, the breeding lines with the best overall quality are: VA08W-193 and Progeny 185. These lines are similar to SS5205 for milling and baking quality.

Lactic acid SRC is a good measure of gluten strength. Based on lactic acid scores, the strongest gluten breeding lines are VA05W-151 and Progeny 117. These lines are not significantly different from Pioneer 26R15 for gluten strength.

We have included for your reference two and three year data summaries for this trial. Progeny 185 also appears to have above average quality in the two year summary. VA05W-151 and Progeny 117 have strong gluten in the two year summary as well as in the current year.

## Brownstown and Urbana Variety Trial – 2010 Crop

Emerson Nafziger, University of Illinois

### Advanced Milling and Baking Evaluation

A total of 65 and 68 samples were grown for a quality study at Brownstown and Urbana Illinois, respectively. Samples were submitted by Emerson Nafziger of the University of Illinois for milling and baking quality evaluations. The standard quality data were compared to the average for the cultivar checks given for this nursery, and quality scores for all entries are adjusted to this average. Of the 261 cultivars in the SWQL database of Advanced Mill Database cultivars, the following table compares six checks from Brownstown and five checks from Urbana with their "historical data" from the Advanced Milling databases.

This study had observable evidence of weathering, black points, pre-sprouting, and FHB infected grain before air aspiration. After air aspiration, shriveling of the grain was present. Our flour analyses, when compared to the historical data of the given checks, found that flour protein and lactic acid SRC were within the expected target range for soft wheat characteristics. Sucrose and sodium carbonate SRCs were below the normal range, while flour yield, softness equivalence, and water SRC were above the range we observe for these cultivars. This supports field weathering of the samples, which normally softens the kernels. The observed scores at Urbana for the five checks correlated to the historical scores at a level of r>0.8, indicating that this trial is predictive of future results. In contrast, the Brownstown observed milling and baking scores for the checks did not correlate well with historical values. The unusually large softness values of this study appear to have compressed the normal range of milling and baking scores for these checks. The Urbana location may be a better source of information for selection of cultivars.

**Table 33. 2010 Brownstown Variety Trial**

| | | | From Advanced Milling Database Scoring | | | | Predicted from Measured Data | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lab Number | Entry Number | ENTRY | Milling Quality Score | Baking Quality Score | Softness Equivalent Score | | Milling Quality Score | | Baking Quality Score | | Softness Equivalent Score | |
| 1051385 | 5 | BRANSON | 66.8 | 75.2 | 77.0 | | 76.3 | B | 101.8 | A | 82.2 | A |
| 1051432 | 54 | Pioneer 25R47 | 72.8 | 94.4 | 80.4 | | 77.4 | B | 113.9 | A | 84.9 | A |
| 1051434 | 56 | Pioneer 25R62 | 66.0 | 75.7 | 64.5 | | 60.4 | C | 87.1 | A | 62.2 | C |
| 1051435 | 57 | Pioneer 25R78 | 68.1 | 74.2 | 69.4 | | 70.5 | B | 92.2 | A | 69.9 | C |
| 1051444 | 66 | Jamestown | 59.9 | 43.1 | 61.0 | | 74.9 | B | 90.5 | A | 72.8 | B |
| 1051445 | 68 | Merl | 69.5 | 72.5 | 66.3 | | 74.0 | B | 88.7 | A | 76.4 | B |
| | | Average | 67.2 | 72.5 | 69.8 | | 72.3 | | 95.7 | | 74.7 | |
| | | Adjustment Bias for Trial | -5.1 | -23.2 | -5.0 | | | | | | | |
| | | Standard Errors used for grading* | | | | | | | | | | |

* Standard errors derive from 5 state, 2 year study of 187 cultivars in the association analysis of soft wheat cultivars

**Table 34.  2010 Urbana Variety Trial**

| | | | From Advanced Milling Database Scoring | | | | Predicted from Measured Data | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lab Number | Entry Number | ENTRY | Milling Quality Score | Baking Quality Score | Softness Equivalent Score | | Milling Quality Score | | Baking Quality Score | | Softness Equivalent Score | |
| | | | | | | | | | | | | |
| 1051454 | 5 | BRANSON | 66.8 | 75.2 | 77.0 | | 73.4 | B | 96.6 | A | 94.8 | A |
| 1051493 | 45 | Pioneer 25R47 | 72.8 | 94.4 | 80.4 | | 77.4 | B | 119.8 | A | 96.7 | A |
| 1051494 | 46 | Pioneer 25R56 | 63.1 | 78.6 | 55.7 | | 68.2 | C | 99.7 | A | 80.9 | A |
| 1051510 | 63 | Jamestown | 59.9 | 43.1 | 61.0 | | 69.7 | C | 90.1 | A | 85.6 | A |
| 1051512 | 65 | Merl | 69.5 | 72.5 | 66.3 | | 71.9 | B | 91.6 | A | 84.4 | A |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | Average | 66.4 | 72.8 | 68.1 | | 72.1 | | 99.6 | | 88.5 | |
| | | Adjustment Bias for Trial | -5.7 | -26.8 | -20.4 | | | | | | | |
| | | Standard Errors used for grading* | | | | | | | | | | |

**2010 Brownstown and Urbana Variety Trial Narrative**

We generated summary trials across the two locations and within each location for the last two years.  Those trials were color coded for preferences based on most milling companies who participate in the Wheat Quality Council.  Because of environmental effects it is often difficult to assign absolute values for any one milling and baking test. The coding indicates if lines were greater or smaller than the average of the check and then if that level was in the direction generally preferred by the millers and bakers.  To interpret the color pattern: lines with one or two red highlights are likely still acceptable but a consistent pattern of red colors indicates a line that may have questionable suitability for soft wheat products (e.g. Excel 302).  Lines with many green highlights are likely to have above average suitability for soft wheat products.  The milling and baking industry uses both strong and weak gluten wheat lines (e.g. FS 610).  Both seem to have value in the market place.  We have color coded lines for gluten strength as measured by the lactic acid SRC value.

# 2010 Wheat Quality Council
## SWQL Evaluation of New Cultivars

Milling and Baking Test Results for New Eastern Soft Winter Wheats Harvested in 2010

**The Quality Evaluation Committee of the Soft Wheat Council**
Edward Souza and Scott Beil, USDA Soft Wheat Quality Laboratory
Meera Kweon, Research Food Technologist, Campbell Soup Corp

**Objectives of Miag Milling New Soft Wheat Cultivars:**

- Encourage wide participation by all members of the soft wheat industry.
- Determine, through technical consulting expertise, the parameters which adequately describe the performance characteristics which members seek in new variety.
- Promote the enhancement of soft wheat quality in new variety.
- Emphasize the importance of communication across all sectors and to provide resources for education on the continuous improvement of soft wheat quality.
- Encourage the organizations vital to soft wheat quality enhancement to continue to make positive contributions through research and communications.
- Offer advice and support for the USDA-ARS Soft Wheat Quality Laboratory in Wooster, Ohio

**Contributors of Test Lines**

| | |
|---|---|
| **Cornell University:** | OH 751<br>Saranac<br>Caledonia (check) |
| **University of Georgia:** | UGS 3120<br>UGS 3295 (check) |
| **Syngenta:** | Arcadia<br>SY 9978<br>Oakes (check) |
| **Michigan State University:** | E5011B<br>E5024<br>Ambassador (check) |

Variety descriptions are found in the **New Wheat Cultivars** section of this report.

# Milling Analysis and Ash Curves

**Miag Multomat Mill**

The Miag Multomat Mill is a pneumatic conveyance system consisting of eight pair of 254 mm diameter x 102 mm wide rolls, and ten sifting passages. Three pairs are corrugated employed as break rolls and five pair are smooth rolls utilized in the reduction process. Each sifting passage contains six separate sieves. The two top sieves for each of the break rolls are intended to be used as scalp screens for the bran. The third break sieving unit of the Soft Wheat Quality Laboratory (SWQL) Miag Multomat Mill was modified so that the top four sieves are employed to scalp bran. That modification increased the final bran sieving surface by 100% and essentially eliminated any loss of flour. Thus, the mill closely approximates full scale commercial milling.

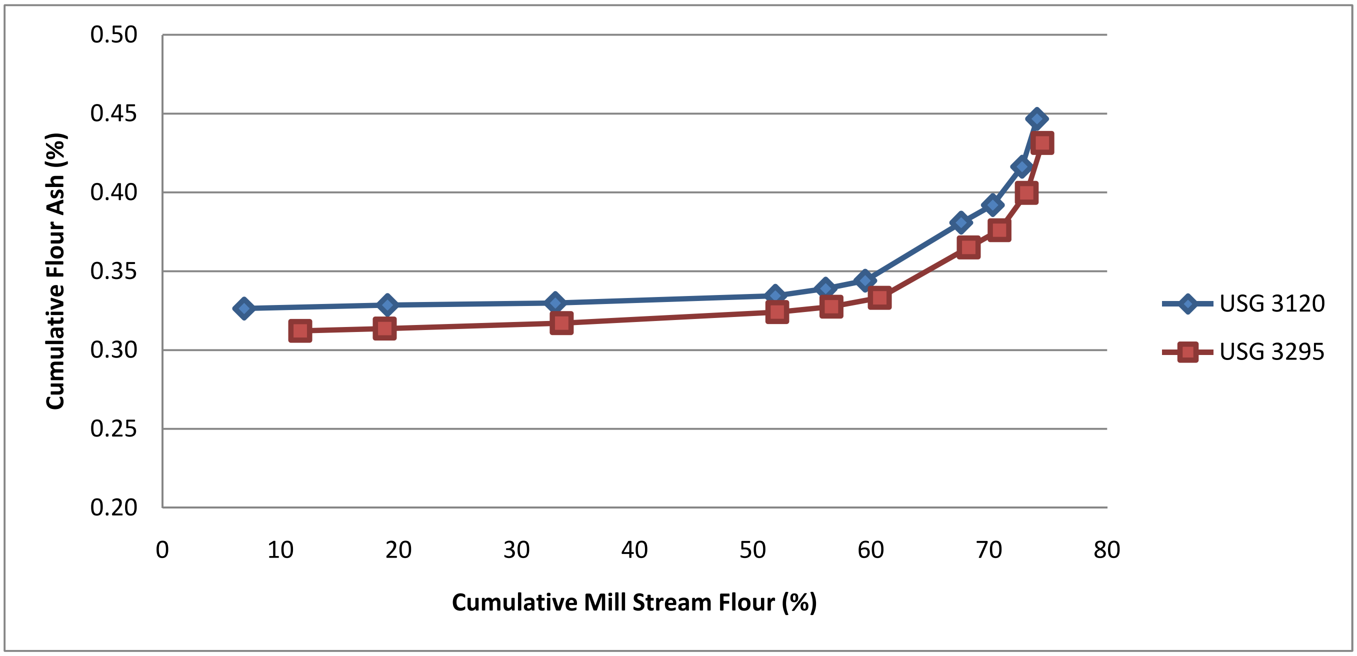
**Experimental Milling Procedure**

All SRW varieties are tempered to a 14.0% moisture level. Generally tempered wheat is held for at least 24 hours in order for the moisture to equilibrate throughout the grain. Wheat is introduced into the first break rolls at a rate of 54.4 Kg/hour (90 #/hour). Straight grade flour is a blend of the three break flour streams including the grader flour and the five reduction streams including the duster flour. The straight grade flour mean volume diameter will be about 50 microns with a flour ash content usually between 0.42% and 0.52%. Flour generated by the (SWQL) Miag Multomat Mill very nearly represents that of commercially produced straight grade flour. Bran, head shorts, tail shorts and red dog are by-products which are not included with the flour. Flour yields will vary between 70% and 78% and are variety-dependent due to milling quality differences and/or grain condition. Sprouted and/or shriveled kernels will negatively impact flour production. Recovery of all mill products will usually be about 99%. Least significant differences for straight grade flour yield and break flour yield are 0.75% and 0.82%, respectively.

**Ash Curves**

Flour was collected from each of the ten flour streams used to compose straight grade flour fractions. Flour ash on the fractions was determined using the basic method (AACC Method 08-01), expressed on 14% moisture basis. Then starting with the lowest ash flour streams, the percent flour recovery was estimated by arithmetically calculating the average ash and total flour recovery predicted by sequentially adding flour streams by order of their flour ash (lowest to highest).

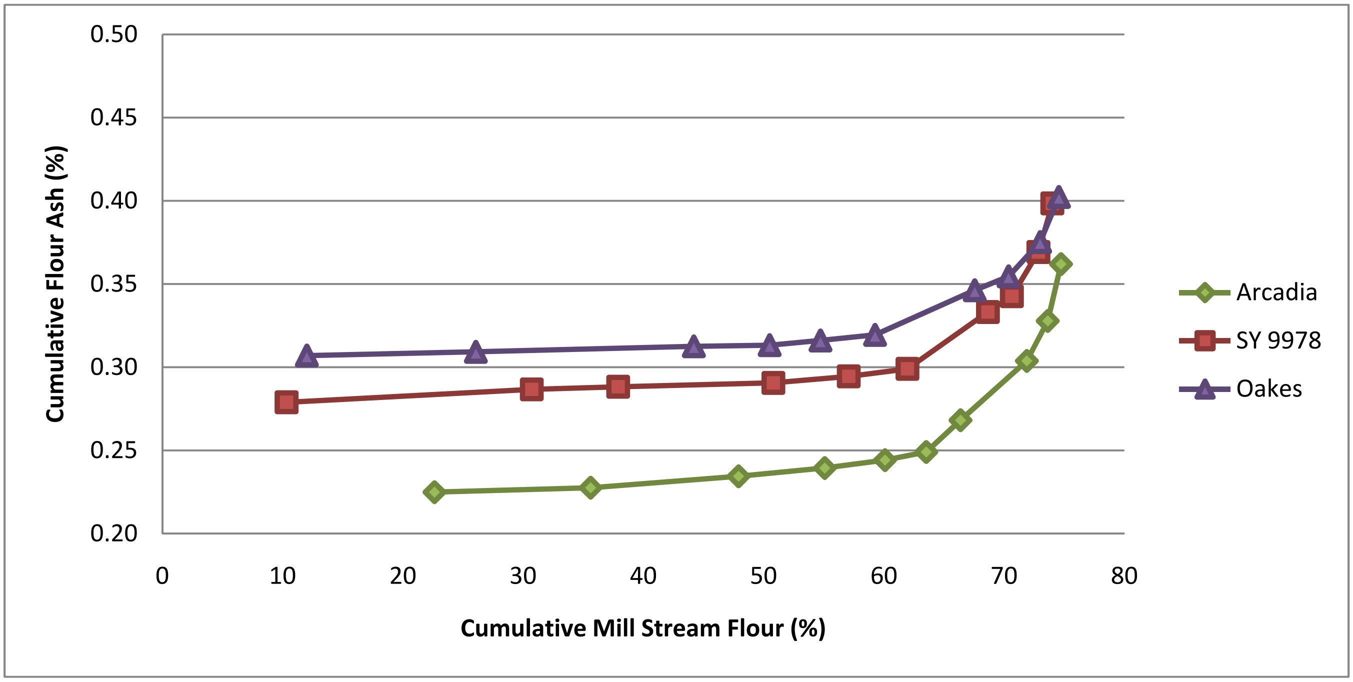
**Figure 3. Milling ash curves for two soft red winter wheat varieties from the University of Georgia, 2010 Wheat Quality Council.**




Mill stream analysis for cumulative ash and flour streams for 2010 WQC samples from the University of Georgia.

| USG 3120 | | | USG 3295 | | |
|---|---|---|---|---|---|
| Mill Stream | Cumulative Stream % | Cumulative Ash % | Mill Stream | Cumulative Stream % | Cumulative Ash % |
| Duster | 6.9 | 0.326 | 1st Reduction | 11.7 | 0.312 |
| 1st Reduction | 19.1 | 0.329 | Duster | 18.8 | 0.314 |
| 2nd Reduction | 33.3 | 0.330 | 2nd Reduction | 33.8 | 0.317 |
| 1st Break | 51.9 | 0.334 | 1st Break | 52.1 | 0.324 |
| Grader | 56.2 | 0.339 | Grader | 56.7 | 0.328 |
| 2nd Break | 59.5 | 0.344 | 2nd Break | 60.7 | 0.333 |
| 3rd Reduction | 67.6 | 0.381 | 3rd Reduction | 68.3 | 0.365 |
| 3rd Break | 70.3 | 0.392 | 3rd Break | 70.9 | 0.376 |
| 4th Reduction | 72.8 | 0.416 | 4th Reduction | 73.2 | 0.400 |
| 5th Reduction | 74.1 | 0.447 | 5th Reduction | 74.5 | 0.431 |
| Red Dog | 74.9 | 0.479 | Red Dog | 75.5 | 0.474 |
| Tail Shorts | 75.3 | 0.493 | Tail Shorts | 75.9 | 0.492 |
| Head Shorts | 82.7 | 0.793 | Head Shorts | 84.1 | 0.905 |
| Bran | 100.0 | 1.605 | Bran | 100.0 | 1.702 |

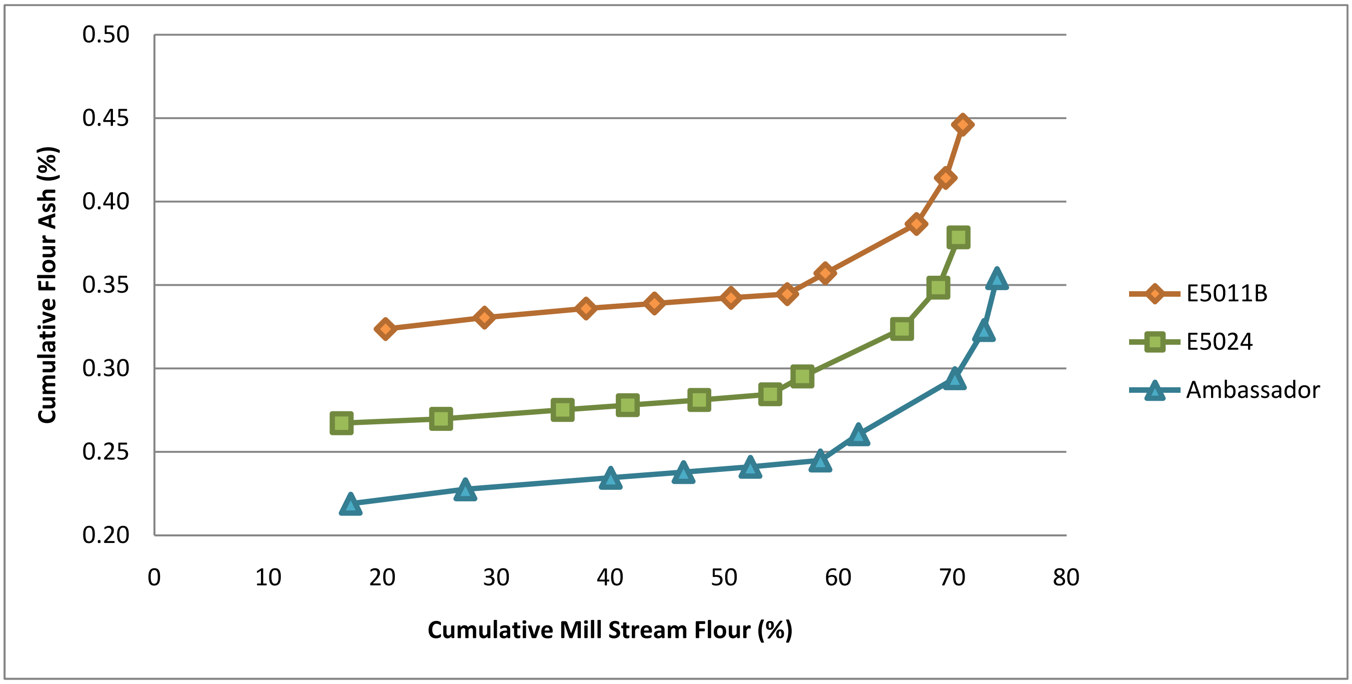
**Figure 4. Milling ash curves for three soft red winter wheat varieties from Syngenta Seeds, Inc., Arkansas, 2010 Wheat Quality Council.**




Mill stream analysis for cumulative ash and flour streams, 2010 WQC samples from Syngenta Seeds, Inc., of Arkansas.

| Arcadia | | | SY 9978 | | | Oakes | | |
|---|---|---|---|---|---|---|---|---|
| Mill Stream | Cumulative Stream % | Cumulative Ash % | Mill Stream | Cumulative Stream % | Cumulative Ash % | Mill Stream | Cumulative Stream % | Cumulative Ash % |
| 1st Break | 22.6 | 0.225 | 1st Reduction | 10.3 | 0.279 | 1st Reduction | 12.0 | 0.307 |
| 1st Reduction | 35.6 | 0.228 | 1st Break | 30.7 | 0.287 | 2nd Reduction | 26.1 | 0.309 |
| 2nd Reduction | 47.9 | 0.235 | Duster | 37.9 | 0.288 | 1st Break | 44.2 | 0.313 |
| Duster | 55.1 | 0.239 | 2nd Reduction | 50.8 | 0.291 | Duster | 50.5 | 0.313 |
| Grader | 60.1 | 0.244 | Grader | 57.1 | 0.295 | Grader | 54.7 | 0.316 |
| 2nd Break | 63.5 | 0.249 | 2nd Break | 62.0 | 0.299 | 2nd Break | 59.3 | 0.319 |
| 3rd Break | 66.4 | 0.268 | 3rd Reduction | 68.7 | 0.333 | 3rd Reduction | 67.6 | 0.346 |
| 3rd Reduction | 71.9 | 0.304 | 3rd Break | 70.6 | 0.343 | 3rd Break | 70.4 | 0.355 |
| 4th Reduction | 73.6 | 0.328 | 4th Reduction | 72.9 | 0.369 | 4th Reduction | 73.0 | 0.375 |
| 5th Reduction | 74.7 | 0.362 | 5th Reduction | 74.0 | 0.398 | 5th Reduction | 74.6 | 0.402 |
| Red Dog | 75.6 | 0.398 | Red Dog | 74.8 | 0.428 | Red Dog | 75.5 | 0.432 |
| Tail Shorts | 76.0 | 0.413 | Tail Shorts | 75.2 | 0.442 | Tail Shorts | 75.9 | 0.444 |
| Head Shorts | 83.9 | 0.770 | Head Shorts | 83.2 | 0.789 | Head Shorts | 84.5 | 0.804 |
| Bran | 100.0 | 1.499 | Bran | 100.0 | 1.627 | Bran | 100.0 | 1.529 |

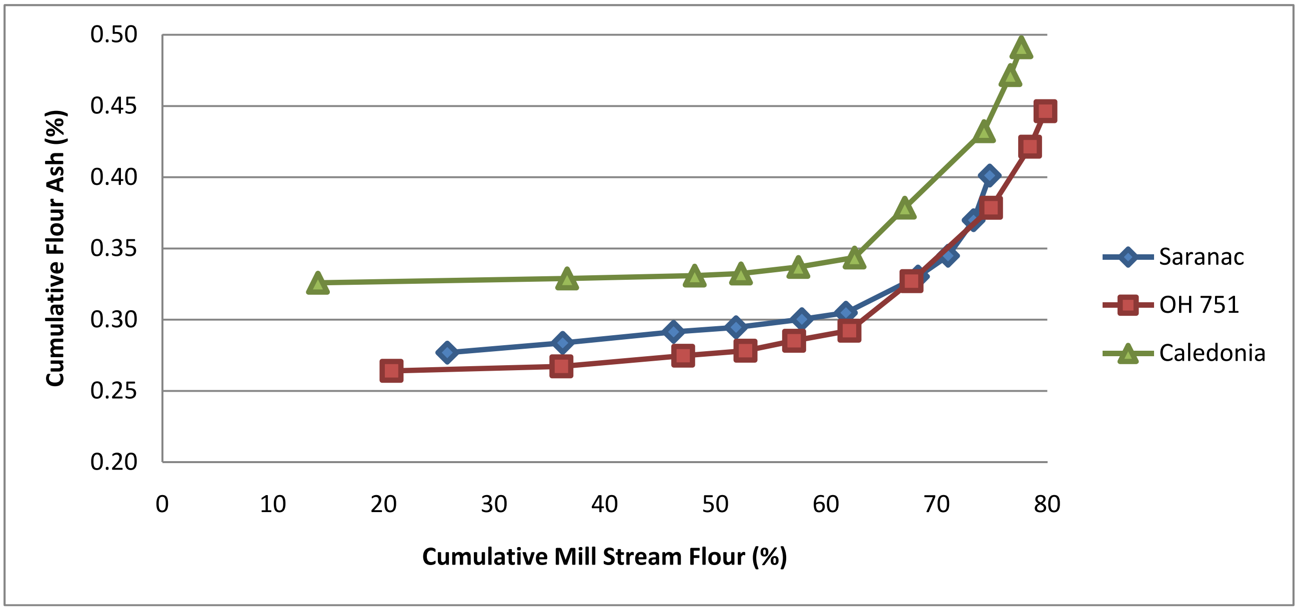
**Figure 5. Milling ash curves for three soft red winter wheat varieties from Michigan State University, 2010 Wheat Quality Council.**




Mill Stream analysis for cumulative ash and flour streams, 2010 WQC samples from Michigan State University.

| E5011B | | | E5024 | | | Ambassador | | |
|---|---|---|---|---|---|---|---|---|
| Mill Stream | Cumulative Stream % | Cumulative Ash % | Mill Stream | Cumulative Stream % | Cumulative Ash % | Mill Stream | Cumulative Stream % | Cumulative Ash % |
| 1st Break | 20.3 | 0.324 | 1st Break | 16.4 | 0.267 | 1st Break | 17.2 | 0.219 |
| 1st Reduction | 29.0 | 0.330 | 1st Reduction | 25.2 | 0.270 | 1st Reduction | 27.3 | 0.228 |
| 2nd Reduction | 37.9 | 0.336 | 2nd Reduction | 35.8 | 0.275 | 2nd Reduction | 40.0 | 0.234 |
| Grader | 43.9 | 0.339 | Duster | 41.5 | 0.278 | Duster | 46.4 | 0.238 |
| 2nd Break | 50.6 | 0.342 | Grader | 47.8 | 0.281 | Grader | 52.3 | 0.241 |
| Duster | 55.5 | 0.345 | 2nd Break | 54.0 | 0.285 | 2nd Break | 58.4 | 0.245 |
| 3rd Break | 58.9 | 0.357 | 3rd Break | 56.9 | 0.295 | 3rd Break | 61.8 | 0.261 |
| 3rd Reduction | 66.9 | 0.387 | 3rd Reduction | 65.6 | 0.324 | 3rd Reduction | 70.2 | 0.294 |
| 4th Reduction | 69.4 | 0.414 | 4th Reduction | 68.8 | 0.348 | 4th Reduction | 72.8 | 0.323 |
| 5th Reduction | 70.9 | 0.446 | 5th Reduction | 70.5 | 0.379 | 5th Reduction | 73.9 | 0.354 |
| Red Dog | 71.9 | 0.479 | Red Dog | 71.7 | 0.411 | Red Dog | 74.8 | 0.394 |
| Tail Shorts | 72.2 | 0.492 | Tail Shorts | 72.0 | 0.421 | Tail Shorts | 75.1 | 0.409 |
| Head Shorts | 79.7 | 0.832 | Head Shorts | 79.8 | 0.748 | Head Shorts | 83.6 | 0.838 |
| Bran | 100.0 | 1.687 | Bran | 100.0 | 1.598 | Bran | 100.0 | 1.596 |

**Figure 6. Milling ash curves for three soft red winter wheat varieties from Cornell University, 2010 Wheat Quality Council.**




Mill Stream analysis for cumulative ash and flour streams, 2010 WQC samples from Cornell University.

| Saranac | | | OH 751 | | | Caledonia | | |
|---|---|---|---|---|---|---|---|---|
| Mill Stream | Cumulative Stream % | Cumulative Ash % | Mill Stream | Cumulative Stream % | Cumulative Ash % | Mill Stream | Cumulative Stream % | Cumulative Ash % |
| 1st Break | 25.8 | 0.277 | 1st Break | 20.7 | 0.264 | 1st Reduction | 14.1 | 0.326 |
| 1st Reduction | 36.2 | 0.284 | 1st Reduction | 36.1 | 0.267 | 1st Break | 36.6 | 0.329 |
| 2nd Reduction | 46.2 | 0.291 | 2nd Reduction | 47.1 | 0.275 | 2nd Reduction | 48.1 | 0.331 |
| Duster | 51.9 | 0.295 | Grader | 52.7 | 0.278 | Grader | 52.3 | 0.332 |
| Grader | 57.8 | 0.300 | Duster | 57.1 | 0.285 | Duster | 57.5 | 0.337 |
| 2nd Break | 61.8 | 0.305 | 2nd Break | 62.1 | 0.292 | 2nd Break | 62.6 | 0.344 |
| 3rd Reduction | 68.3 | 0.330 | 3rd Break | 67.7 | 0.327 | 3rd Break | 67.1 | 0.379 |
| 3rd Break | 71.0 | 0.345 | 3rd Reduction | 74.9 | 0.379 | 3rd Reduction | 74.3 | 0.432 |
| 4th Reduction | 73.3 | 0.370 | 4th Reduction | 78.4 | 0.421 | 4th Reduction | 76.7 | 0.472 |
| 5th Reduction | 74.8 | 0.401 | 5th Reduction | 79.8 | 0.446 | 5th Reduction | 77.7 | 0.491 |
| Red Dog | 75.9 | 0.435 | Red Dog | 80.2 | 0.458 | Red Dog | 78.0 | 0.503 |
| Tail Shorts | 76.2 | 0.445 | Tail Shorts | 80.3 | 0.465 | Tail Shorts | 78.2 | 0.512 |
| Head Shorts | 83.3 | 0.734 | Head Shorts | 88.6 | 0.866 | Head Shorts | 86.1 | 0.865 |
| Bran | 100.0 | 1.523 | Bran | 100.0 | 1.472 | Bran | 100.0 | 1.573 |

**Table 35. USDA-ARS Soft Wheat Quality Laboratory grain evaluation for 11 soft winter wheat cultivars, 2010 Wheat Quality Council.**

| | Primary Analysis | | | | | Milling | | SKCS | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Variety | Flour Moisture % | Flour Protein % | Flour pH | Falling # | Flour Ash % | Break Flour | Straight Grade Flour | Hardness Ave | Weight Ave | Moisture Ave | Diameter Ave |
| USG 3120 (SRW) | 13.9 | 8.12 | 6.10 | 405 | 0.382 | 28.9 | 73.9 | 27.87 | 37.44 | 11.96 | 2.46 |
| USG 3295 (CK) (SRW) | 13.6 | 9.56 | 6.12 | 456 | 0.411 | 29.5 | 74.4 | 18.42 | 33.34 | 11.81 | 2.47 |
| Arcadia (SRW) | 14.0 | 8.96 | 6.12 | 438 | 0.374 | 33.9 | 74.7 | 14.35 | 37.71 | 12.89 | 2.59 |
| SY 9978 (SRW) | 14.0 | 8.37 | 6.24 | 427 | 0.371 | 33.5 | 73.9 | 5.53 | 35.64 | 12.40 | 2.38 |
| Oakes (CK) (SRW) | 14.1 | 7.66 | 6.19 | 419 | 0.387 | 29.7 | 74.4 | 24.93 | 34.39 | 12.53 | 2.47 |
| E5011B (SWW) | 13.8 | 9.47 | 6.17 | 288 | 0.412 | 36.3 | 70.8 | 6.99 | 32.24 | 12.29 | 2.24 |
| E5024 (SWW) | 14.0 | 9.91 | 6.08 | 311 | 0.361 | 31.7 | 70.5 | 14.95 | 27.96 | 11.65 | 2.06 |
| Ambassador (CK) (SWW) | 13.9 | 9.74 | 5.83 | 117 | 0.344 | 32.5 | 73.7 | 2.89 | 35.35 | 12.65 | 2.42 |
| Saranac (SWW) | 14.2 | 7.28 | 6.23 | 273 | 0.402 | 38.1 | 74.2 | 11.84 | 36.56 | 14.37 | 2.49 |
| OH 751 (SRW) | 14.1 | 6.81 | 6.13 | 317 | 0.309 | 35.7 | 77.2 | 8.49 | 36.87 | 13.88 | 2.49 |
| Caledonia (CK) (SWW) | 14.1 | 7.61 | 6.28 | 353 | 0.393 | 34.6 | 74.0 | 13.14 | 41.89 | 14.56 | 2.66 |

**Table 36. USDA-ARS Soft Wheat Quality Laboratory flour evaluation of 11 soft winter wheat cultivars for 2010 Wheat Quality Council.**

| | | Alpha Amylase | | Damaged Starch | | | Solvent retention capacity | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Variety | Ave Units (CU/g) | Ave Falling # | Reading 1 | Reading 2 | Ave | Water % | Sodium Carb % | 5g Sucrose % | Lactic Acid % | LA/ SC+S |
| Set 1 | USG 3120 (SRW) | 0.061 | 405 | 3.86 | 3.81 | 3.84 | 54.3 | 69.2 | 87.2 | 83.0 | 0.531 |
| | USG 3295 (CK) (SRW) | 0.058 | 456 | 3.41 | 3.53 | 3.47 | 54.0 | 67.5 | 93.0 | 86.9 | 0.541 |
| Set 2 | Arcadia (SRW) | 0.033 | 438 | 1.82 | 1.90 | 1.86 | 51.6 | 64.6 | 88.4 | 104.4 | 0.683 |
| | SY 9978 (SRW) | 0.040 | 427 | 1.82 | 1.85 | 1.84 | 51.3 | 68.9 | 81.3 | 103.7 | 0.690 |
| | Oakes (CK) (SRW) | 0.072 | 419 | 3.62 | 3.54 | 3.58 | 53.7 | 67.4 | 85.9 | 91.2 | 0.595 |
| Set 3 | E5011B (SWW) | 0.109 | 288 | 1.53 | 1.42 | 1.48 | 55.0 | 79.9 | 90.0 | 115.6 | 0.681 |
| | E5024 (SWW) | 0.088 | 311 | 1.96 | 1.83 | 1.90 | 53.5 | 76.2 | 95.0 | 114.7 | 0.670 |
| | Ambassador (CK) (SWW) | 0.586 | 117 | 1.42 | 1.51 | 1.47 | 50.6 | 70.6 | 89.4 | 116.4 | 0.728 |
| Set 4 | Saranac (SWW) | 0.110 | 273 | 1.96 | 1.99 | 1.98 | 51.5 | 66.4 | 80.5 | 81.1 | 0.553 |
| | OH 751 (SRW) | 0.059 | 317 | 2.71 | 2.82 | 2.77 | 54.5 | 68.6 | 86.6 | 91.2 | 0.588 |
| | Caledonia (CK) (SWW) | 0.057 | 353 | 3.31 | 3.34 | 3.33 | 52.9 | 67.9 | 82.2 | 100.2 | 0.667 |

**Table 37. USDA-ARS Soft Wheat Quality Laboratory mixograph and RVA analysis of 11 soft winter wheat cultivars for 2010 Wheat Quality Council.**

| | | Mixograph | | | | Rapid Visco Analyzer | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Variety | Peak Time min | Peak Value % | Peak Width % | Peak Width 7min | Peak Time | Peak cP | Trough cP | Break-down cP | back cP | Final cP | Pasting Temp °C | Peak/ Final Ratio |
| 1 | USG 3120 (SRW) | 0.62 | 37.1 | 19.5 | 9.3 | 6.07 | 2179 | 1305 | 875 | 1252 | 2557 | 85.1 | 0.85 |
| | USG 3295 (CK) (SRW) | 3.37 | 43.9 | 15.2 | 5.4 | 6.27 | 2700 | 1858 | 843 | 1533 | 3390 | 86.0 | 0.80 |
| 2 | Arcadia (SRW) | 4.55 | 43.2 | 19.3 | 8.7 | 6.33 | 3049 | 2001 | 1048 | 1509 | 3510 | 85.5 | 0.87 |
| | SY 9978 (SRW) | 4.67 | 38.2 | 14.9 | 9.2 | 6.30 | 2804 | 1768 | 1036 | 1402 | 3170 | 86.3 | 0.88 |
| | Oakes (CK) (SRW) | 0.72 | 36.1 | 19.8 | 10.0 | 6.27 | 2959 | 1877 | 1083 | 1478 | 3355 | 75.9 | 0.88 |
| 3 | E5011B (SWW) | 2.16 | 42.9 | 20.3 | 9.1 | 5.43 | 1457 | 640 | 818 | 792 | 1432 | 81.2 | 1.02 |
| | E5024 (SWW) | 5.68 | 39.0 | 13.9 | 11.7 | 5.93 | 1902 | 1055 | 847 | 1146 | 2201 | 86.4 | 0.86 |
| | Ambassador (CK) (SWW) | 3.27 | 44.4 | 13.0 | 3.6 | 3.73 | 366 | 34 | 332 | 21 | 55 | 69.4 | 6.72 |
| 4 | Saranac (SWW) | 3.94 | 30.5 | 11.2 | 8.3 | 5.60 | 1556 | 610 | 946 | 799 | 1409 | 83.2 | 1.10 |
| | OH 751 (SRW) | 0.76 | 35.0 | 18.1 | 10.0 | 5.90 | 2624 | 1412 | 1212 | 1376 | 2788 | 83.9 | 0.94 |
| | Caledonia (CK) (SWW) | 4.22 | 36.0 | 13.2 | 9.3 | 6.07 | 2294 | 1366 | 928 | 1308 | 2674 | 86.3 | 0.86 |

**Table 38. USDA-ARS Soft Wheat Quality Laboratory cracker and wire-cut cookie of 11 soft winter wheat cultivars for 2010 Wheat Quality Council.**

| | | Crackers | | | Wire-cut cookies (10-54) | | | | Sugar snap cookies | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Variety | Ht/Dough Wt Ratio | W/L Ratio | Blisters | Cookie Diameter cm x2 | Cookie Stack Ht cm x2 | Punch Force g | Distance mm | Cookie Diameter cm x2 | Top Grain Score |
| Set 1 | USG 3120 (SRW) | 0.109 | 0.87 | | 15.12 | 2.19 | 1142 | 2.53 | 18.24 | 6 |
| | USG 3295 (CK) (SRW) | 0.145 | 0.81 | *** | 15.12 | 2.28 | 1320 | 2.45 | 17.60 | 4 |
| Set 2 | Arcadia (SRW) | 0.107 | 0.83 | | 15.97 | 2.16 | 1076 | 2.30 | 18.69 | 5 |
| | SY 9978 (SRW) | 0.115 | 0.81 | * | 16.05 | 2.04 | 1086 | 3.11 | 18.78 | 4 |
| | Oakes (CK) (SRW) | 0.105 | 0.85 | | 15.52 | 2.13 | 1118 | 1.84 | 18.50 | 5 |
| Set 3 | E5011B (SWW) | 0.118 | 0.83 | * | 16.06 | 2.15 | 1080 | 2.23 | 18.14 | 5 |
| | E5024 (SWW) | 0.135 | 0.82 | ** | 15.20 | 2.33 | 1361 | 2.35 | 17.60 | 3 |
| | Ambassador (CK) (SWW) | 0.134 | 0.81 | * | 15.71 | 2.16 | 1142 | 2.74 | 18.15 | 4 |
| Set 4 | Saranac (SWW) | 0.113 | 0.83 | | 16.08 | 2.01 | 1041 | 2.08 | 19.25 | 7 |
| | OH 751 (SRW) | 0.117 | 0.85 | | 16.32 | 2.03 | 1037 | 1.39 | 19.19 | 7 |
| | Caledonia (CK) (SWW) | 0.106 | 0.84 | | 16.36 | 1.96 | 1020 | 2.30 | 18.95 | 5 |

Note: *, **, *** indicate that crackers have 1-3 small blisters, 4-7 small blisters, and 8 large blisters, respectively.

**Genotyping for Quality Traits: 2010 Wheat Quality Council**
**Anne Sturbaum**

Genotyping was done at the Soft Wheat Quality Lab and the Regional Small Grains Genotyping Laboratory in Raliegh, N.C**.** for the 11 varieties: Ambassador, Arcadia, Caledonia, E5024, E5011B, Oakes, OH751, Saranac, SY9978, USG3120, USG3295. Checks for this group include Ambassador, Caledonia, Oakes and USG3295.

Amplification for high molecular weight glutenins at the *GluA1* locus, using the marker umn19, identified the *Ax2** genotype in Arcadia, E5011B, Saranac and USG3120. This source for Oakes was heterozygous at this locus. All other varieties had the *Ax1* genotype (Liu S. C., 2008) (Ma, 2003).

Primers identifying a 45 bp insertion specific to the *Bx7* over-expressing allele indicated over-expressing *Bx7* for two lines, Ambassador and SY9978. All other varieties produced a product indicative of the wild type allele at this locus (Guttieri, 2008).

Primers specific for *GluD1*, *Dx5* (Guttieri, 2008), generated a PCR product corresponding to the "5+10" genotype in E5024 and USG3120. All other varieties produced amplification products specific for the "2+12" allele (Wan, 2005).

Allele-specific primers identified the *GliD1.2* allele γ-gliadin for USG3295. All other varieties had the GliD1.1 allele (Zhang W. G., 2003).

The 1B/1R rye translocation was identified in varieties E5024, USG3120 and USG3295, as they produced an amplification product with scm9F primers specific for rye ω-secalin using the Scm9 marker pair (Saal, 1999) (de Froidmond, 1998).

All genotypes in this set produced the anticipated banding patterns for normal amylose genotypes (non-waxy) at both the A and B GBSS loci (Nakamura, 2002).

Alleles of the *Vp1B* gene (Viviparous-1), as assayed using Vp1B3 primers, are associated with tolerance to preharvest sprouting. Oakes and E5024 produced a 569 bp product indicating tolerance to PHS. All other varieties amplified the larger product (652 bp), indicating probable susceptibility to PHS (Yang, 2007).

Dwarfing genes were tested using markers specific for *Rht1, Rht2* and *Rht8*. Only SY9978 amplified the *Rht1* allele, all others except OH751 were positive for *Rht2*, and USG3120 had both the *Rht2* and *Rht8* alleles (Zhang X. Y., 2006).

The semi-dominant *Photperiod-D1a* (*Ppd-D1a*) allele confers photoperiod insensitivity in wheat, allowing early flowering. All the varieties tested produced a product indicating the favorable photoperiod allele except for Caledonia, E5011B, OH751, Saranac and USG3120 (Beales, 2007).

The presence of a stem rust resistance gene, *Sr36*, was tested using the marker wmc477. A 185 base pair amplification product indicates the presence of a translocation from *Triticum timopheevi* conferring resistance to the stem rust pathogen. Arcadia, OH751, USG3295, amplified the allele for resistance. Oakes was heterozygous, while the other varieties amplified the wild type product at this locus (Tsilo, 2008).

Markers associated with two QTL for resistance to Fusarium Head Blight located on chromosomes 3BS (Umn10) and 5A (gwm304 and wmc705) were tested against this set of varieties. Favorable resistance alleles were identified for Saranac on 3BS, and E5024 on 5A from Ernie (Liu S. P., 2008) (McCartney, 2007).

See Genotyping Bibliography in the Materials and Methods Section.

# 2009 Overseas Varietal Analysis

Reported by: Dr. Edward Souza
USDA-ARS Soft Wheat Quality Laboratory

2009 Crop Soft Red Winter Wheat
International Collaborator Assessments of Wheat and Flour Samples

China
Colombia
Dominican Republic
Indonesia
Malaysia
Mexico
Peru
Philippines
Thailand
United Arab Emirates



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ACKNOWLEDGEMENTS

On behalf of U.S. Wheat Associates, Arkansas Wheat Promotion Board, Maryland Grain Producers Utilization Board, Virginia Small Grains Board, and the USDA-ARS Soft Wheat Quality Laboratory (SWQL), we wish to extend our appreciation to the overseas cooperators for providing an unbiased evaluation of the quality of U.S. Soft Red Winter wheat varieties. Countries involved in the Overseas Varietal Analysis (OVA) program were China, Colombia, Indonesia, Malaysia, Peru, Philippines, Thailand, and United Arab Emirates.

The author wishes to thank the staff of the USDA ARS Soft Wheat Quality Laboratory at Wooster, Ohio, for providing quality data. The author also wishes to thank the members of the Arkansas Wheat Promotion Board, the Maryland Grain Producers Utilization Board and the Virginia Small Grain Board for supporting this important evaluation.

# Executive Summary of International Results

**Wheat Sources and Characteristics**

The 2009 U.S. Wheat Associates Overseas Varietal Analysis evaluated ten soft red winter wheat varieties: USG 3665 and DK 9577 from Arkansas, Branson, Coker 9553, Coker 9804, Pioneer 26R15, and Pioneer 26R22 from North Carolina, and Dominion, Shirley, and USG 3555 from Virginia. All samples are graded US #2. The summary that follows is primarily based on the summary rankings of the samples in Table 6.

**Product Preferences**

1) Across all cooperators that evaluated cookies, the USG 3665, Pioneer 26R15, and Shirley samples were ranked as most preferred for cookies. The least preferred were Dominion and Coker 9804; both of these samples also were poor for cookie quality as measured by the SWQL.
2) The OVA samples were evaluated for use in at least three different cake formulas and two styles. The Dominion and USG 3555 samples were the most preferred samples, even more than local control flours, for two similar styles: chiffon and western. DK 9577 and Pioneer 26R22 were the most preferred samples for sponge cakes. The best predictors of sponge cake ranking were Alveograph P and W values ($r>0.7$), where samples with larger P and W values had less preferred rankings. The ranking for the two styles of cake were uncorrelated in this study as in previous years.
3) The USG 3555 and Pioneer 25R15 were ranked as the most favored samples for steam bread (Table 6). They were similar in ranking to the local control.

**Summary of Cultivars**

USG 3555 had the best average rank (5.1, Table 6) across all cooperators and all products. Following, USG 3555 was a group of three cultivars with similar ranking, Pioneer 25R15, Shirley, and USG 3665. In evaluations for North American millers, the four leading samples represent different types of end-use quality. USG 3555 is a high break flour cultivar well adapted to cakes while Shirley and USG 3665 are weak gluten types well adapted for general soft wheat use. Pioneer 25R15, and to a lesser extent USG 3555, are stronger gluten cultivars. These samples represent the range of desirable target quality within the soft red winter class for the eastern United States.

**Recommendations for Class**

Each customer in the survey has a preference for specific protein targets. Grain shipments within those protein ranges may perform better than individual varieties that often have a wider range in protein than normally observed in pooled cargos of commercial grain shipments. The feedback on protein concentration and gluten strength should be used to refine targets for marketing to specific customers. In a number of the evaluations, the straight grade flour sample provided may not have been suitable for the product tested by the customer. In some cake comparisons, using patent flour samples would have improved the scores of samples. In other cases the low water absorption of the product resulted in excessive spreading of cookies and too small of stack height for the customer. Increasing flour extraction would correct these deficiencies and improve the profitability of the milling operation. This is an important marketing point for soft red winter; the optimum milling point for some customers in Asia may be at much greater extraction than the straight grade flour samples provided in this study, and might represent an advantage relative to non-US sources of low protein grain. Finally, predicting chiffon cake performance is difficult based on the current quality testing within the eastern US soft wheat region. The varieties ranked as best for chiffon cakes anecdotally known to be good for producing cake flour, but are generally poor for other soft wheat characteristics. Research is needed to develop rapid tests to identify wheat varieties suitable for the range of cakes that are made using soft red winter wheat.

## USDA-ARS Soft Wheat Quality Laboratory Evaluation

**Milling Characteristics (Figures 7-9)**

Flour samples were milled on the SWQL Miag Multomat flour mill. Ash curves were used to measure the milling characteristics of the varieties in a long-flow mill. Flour ash is the mineral concentration of the mill-stream. The center of a kernel is typically low in mineral content compared with the aleurone and bran layers, which have high concentrations of minerals. The mill stream analysis depicts the increase in flour ash as a function of flour recovery.

Cumulative ash curves for wheat varieties were grouped by state of origin for visualization of differences. Because the samples were obtained from different fields in different parts of the states, each curve represents both the genetics and the environment that produced the samples. The ash curves should have flat lines initially, with all the first streams of flour having very similar, low ash levels. Within the North Carolina samples (Figure 8), Pioneer 25R15 and 25R22 best represent the idealized curve.

**Grain Characteristics (Table 39)**
The varieties were within the normal range of soft wheat protein samples. Coker 9804 and Coker 9553 had grain protein levels greater than 11%. None of the samples had grain protein less than 9%. All samples had grain hardness values of less than 50, consistent with being soft wheat samples. Falling number levels were greater than 300 for all samples and greater than 400 for most, consistent with sound unsprouted grain.

**Milling, Proximate, and Alveograph Flour Analysis (Table 40)**
The samples with the best straight grade flour extraction were DK 9577 and Pioneer 25R22, with 75% or greater flour extraction. Branson, USG 3665, and DK 9577 had the greatest break flour yield, significantly greater than 30%. Flour ash was not correlated to flour yields in this study and all four samples were below 0.5% ash. In the Alveograph analyses, all samples had small to moderate P vaules (< 60 mm) but a wide range in W values.

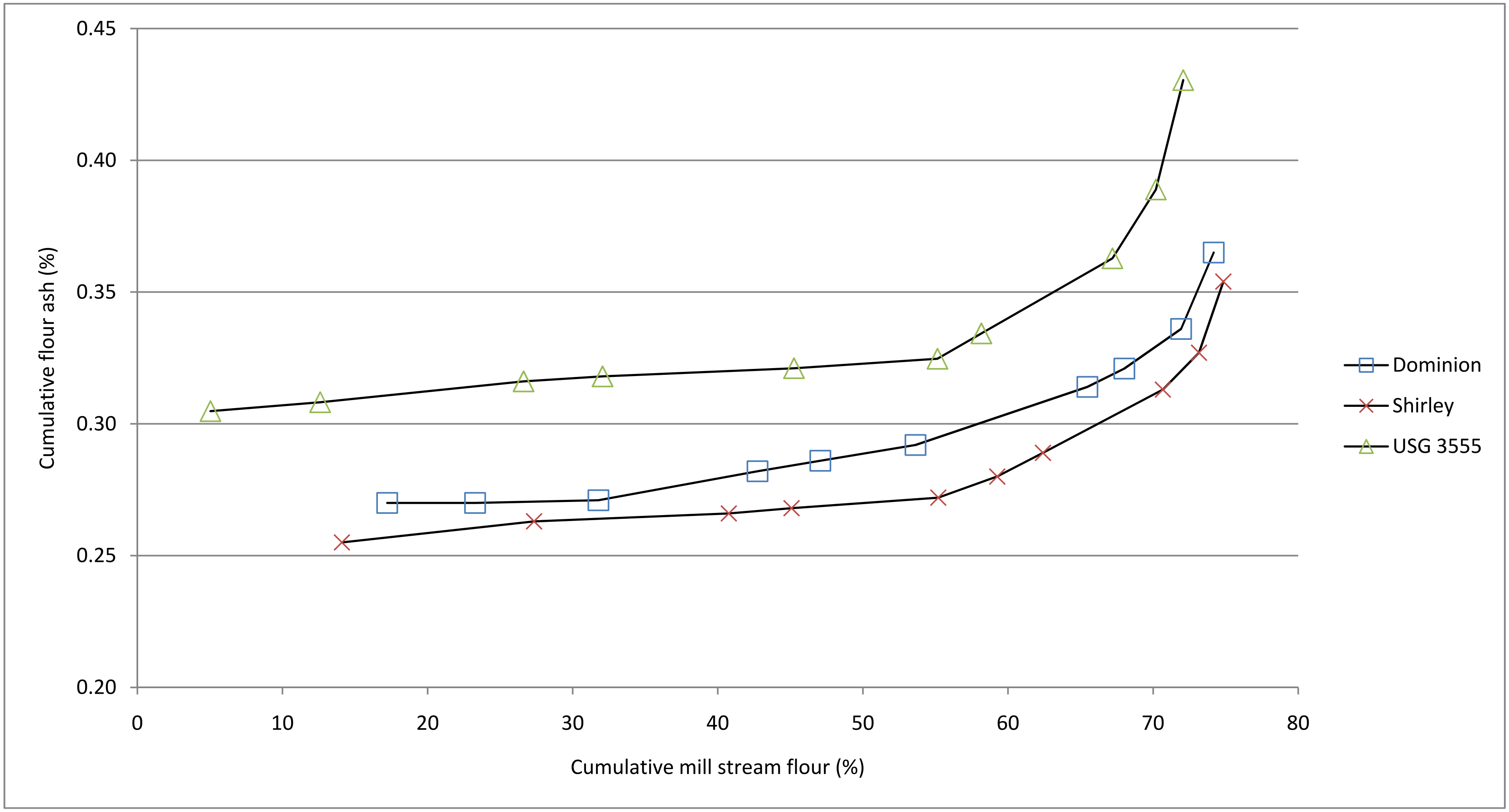
**Solvent Retention Capacity Tests and Bake Evaluations (Table 41)**
The Branson, Pioneer 26R22, and Pioneer 26R15 had the smallest flour water absorption, less than 54%. The greatest water absorption values were in samples of Dominion and Coker 9804. However, all of these flour samples are low water absorption by international standards and are consistent with the soft wheat characteristics. Similarly, significant variation is present in this set for sodium carbonate and sucrose SRC values, yet all are within the expected range for soft wheat varieties. The lactic acid SRC values, which measure gluten strength, were greatest in Coker 9553 and smallest in Shirley. These two wheat varieties also had the largest and smallest Alveograph W values, respectively. Among soft wheat samples, arabinoxylans often have a greater contribution than gluten to the total amount of work required for the Alveograph. In this dataset, we found little correlation between sucrose SRC and Alveograph but positive correlations between lactic acid SRC and Alveograph P and W ($r>0.7$). This suggests that variation in gluten strength is likely a greater contributor to overall dough rheology than arabinoxylan content.

For the wire-cut cookie test, the traditional preference is for larger diameters, smaller stack heights, and small forces required for snapping. By these standards, the DK 9577, Pioneer 26R22, USG 3665, and Branson samples had the best cookie performance with the largest diameters. The stack height and snapping force for these samples also were the lowest of the set, which is consistent with all three measures being correlated and strongly interrelated.

**Rapid Visco-Analysis (Table 42)**
All samples were consistent with the flour coming from sound grain with minimal alpha-amylase activity, as the initial peaks were similar and large for all samples. The ratio of the initial peak flour viscosity to the final peak flour viscosity is diagnostic for wheat varieties that have reduced amylose concentrations (partial-waxy). The initial peak viscosity in a partial waxy genotype typically is elevated and the final viscosity is reduced to give a ratio greater than 1.2. All of the varieties in this set had ratios of peak to final flour viscosity that were consistent with the lines having normal amylopectin:amylose ratios (Wild type, non-partial waxy wheat) except Coker 9804. The Coker 9804 sample had a peak to final ratio of 1.28 but genetic analysis did not find it to carry a gene for partial waxy starch (GBSS mutant). The greater protein content of the grain (<12%) may have contributed to its unusual pasting characteristics.

**Summary of SWQL and Cooperator Data (Table 43)**
Several of the flour analyses were performed by multiple cooperators and/or the SWQL. We took an average of the evaluations for flour protein, flour ash, falling number, Glutomatic, Alveograph, and Farinograph analyses.

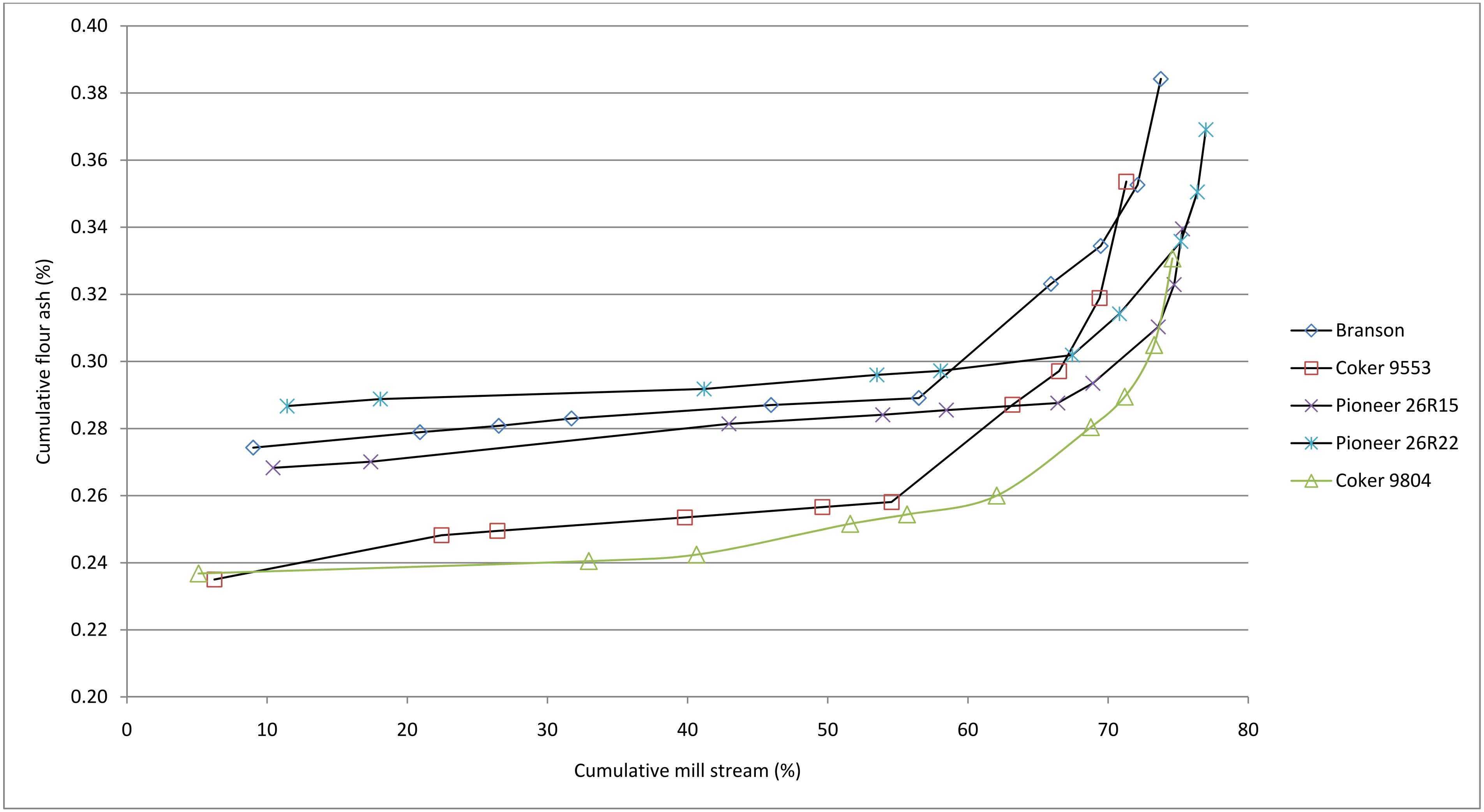
**Figure 7. Milling ash curves for three soft red winter wheat varieties from Virginia for the US Wheat Associates, 2009 Overseas Varietal Analysis.**



Mill stream analysis for cumulative ash and flour streams for 2009 OVA samples from Virginia.

| Dominion | | | Shirley | | | USG 3555 | | |
|---|---|---|---|---|---|---|---|---|
| Mill Stream | Cumulative Stream % | Cumulative ash % | Mill Stream | Cumulative Stream % | Cumulative ash % | Mill Stream | Cumulative Stream % | Cumulative ash % |
| 2nd Reduction | 17.2 | 0.270 | 1st Reduction | 14.1 | 0.255 | Duster | 5.0 | 0.305 |
| Duster | 23.3 | 0.270 | 2nd Break | 27.3 | 0.263 | 1st Reduction | 12.6 | 0.308 |
| 1st Reduction | 31.8 | 0.271 | 2nd Reduction | 40.8 | 0.266 | 2nd Break | 26.6 | 0.316 |
| 2nd Break | 42.7 | 0.282 | Grader | 45.1 | 0.268 | Grader | 32.1 | 0.318 |
| Grader | 47.1 | 0.286 | 1st Break | 55.2 | 0.272 | 2nd Reduction | 45.2 | 0.321 |
| 1st Break | 53.6 | 0.292 | Duster | 59.3 | 0.280 | 1st Break | 55.1 | 0.325 |
| 3rd Reduction | 65.5 | 0.314 | 3rd Break | 62.4 | 0.289 | 3rd Break | 58.2 | 0.334 |
| 3rd Break | 68.0 | 0.321 | 3rd Reduction | 70.7 | 0.313 | 3rd Reduction | 67.2 | 0.363 |
| 4th Reduction | 71.9 | 0.336 | 4th Reduction | 73.2 | 0.327 | 4th Reduction | 70.2 | 0.389 |
| 5th Reduction | 74.2 | 0.365 | 5th Reduction | 74.8 | 0.354 | 5th Reduction | 72.1 | 0.430 |
| Red Dog | 75.8 | 0.415 | Red Dog | 76.3 | 0.402 | Red Dog | 73.8 | 0.499 |
| Tail Shorts | 76.3 | 0.431 | Tail Shorts | 76.7 | 0.416 | Tail Shorts | 74.3 | 0.518 |
| Head Shorts | 83.8 | 0.719 | Head Shorts | 85.1 | 0.770 | Head Shorts | 82.9 | 0.902 |
| Bran | 100.0 | 1.426 | Bran | 100.0 | 1.401 | Bran | 100.0 | 1.597 |

**Figure 8. Milling ash curves for five soft red winter wheat varieties from North Carolina for the US Wheat Associates, 2009 OVA.**



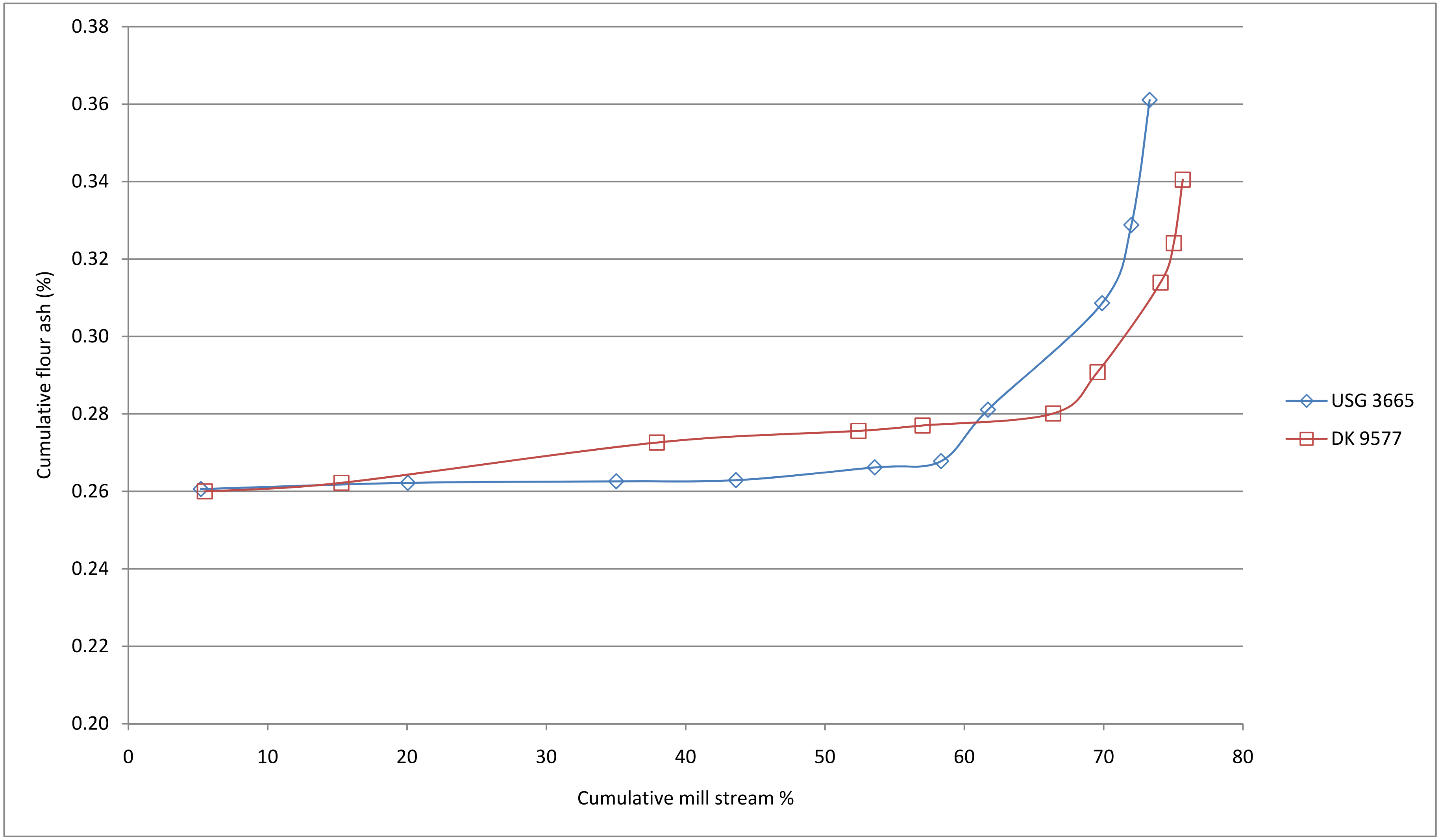
Mill stream analysis for cumulative ash and flour streams for 2009 OVA samples from North Carolina.

| | Branson | | | Coker 9553 | | | Coker 9884 | |
|---|---|---|---|---|---|---|---|---|
| Mill Stream | Cumulative Stream % | Cumulative ash % | Mill Stream | Cumulative Stream % | Cumulative ash % | Mill Stream | Cumulative Stream % | Cumulative ash % |
| 1st Reduction | 9.0 | 0.274 | 1st Reduction | 6.2 | 0.235 | Duster | 5.1 | 0.237 |
| 2nd Reduction | 20.9 | 0.279 | 2nd Reduction | 22.4 | 0.248 | 2nd Reduction | 32.9 | 0.241 |
| Duster | 26.5 | 0.281 | Duster | 26.4 | 0.250 | 1st Reduction | 40.6 | 0.242 |
| Grader | 31.7 | 0.283 | 2nd Break | 39.8 | 0.254 | 2nd Break | 51.6 | 0.252 |
| 2nd Break | 46.0 | 0.287 | 1st Break | 49.6 | 0.257 | Grader | 55.7 | 0.254 |
| 1st Break | 56.5 | 0.289 | Grader | 54.6 | 0.258 | 1st Break | 62.0 | 0.260 |
| 3rd Reduction | 65.9 | 0.323 | 3rd Reduction | 63.2 | 0.287 | 3rd Reduction | 68.8 | 0.280 |
| 3rd Break | 69.5 | 0.334 | 3rd Break | 66.5 | 0.297 | 3rd Break | 71.2 | 0.290 |
| 4th Reduction | 72.1 | 0.353 | 4th Reduction | 69.4 | 0.319 | 4th Reduction | 73.3 | 0.305 |
| 5th Reduction | 73.8 | 0.384 | 5th Reduction | 71.3 | 0.354 | 5th Reduction | 74.6 | 0.331 |
| Red Dog | 75.3 | 0.436 | Red Dog | 72.8 | 0.399 | Red Dog | 75.8 | 0.374 |
| Tail Shorts | 75.7 | 0.450 | Tail Shorts | 73.2 | 0.412 | Tail Shorts | 76.3 | 0.391 |
| Head Shorts | 85.1 | 0.819 | Head Shorts | 82.4 | 0.760 | Head Shorts | 85.3 | 0.711 |
| Bran | 100.0 | 1.409 | Bran | 100.0 | 1.487 | Bran | 100.0 | 1.327 |

Mill stream analysis for cumulative ash and flour streams for 2009 OVA samples from North Carolina (Continued).

| | Pioneer 26R15 | | | Pioneer 26R22 | |
|---|---|---|---|---|---|
| Mill Stream | Cumulative Stream % | Cumulative ash % | Mill Stream | Cumulative Stream % | Cumulative ash % |
| 1st Reduction | 10.4 | 0.268 | 1st Reduction | 11.4 | 0.287 |
| Duster | 17.4 | 0.270 | Duster | 18.1 | 0.289 |
| 2nd Reduction | 42.9 | 0.281 | 2nd Reduction | 41.2 | 0.292 |
| 2nd Break | 53.9 | 0.284 | 2nd Break | 53.5 | 0.296 |
| Grader | 58.5 | 0.286 | Grader | 58.0 | 0.297 |
| 1st Break | 66.4 | 0.288 | 1st Break | 67.4 | 0.302 |
| 3rd Break | 68.9 | 0.294 | 3rd Break | 70.8 | 0.314 |
| 3rd Reduction | 73.6 | 0.310 | 3rd Reduction | 75.2 | 0.336 |
| 4th Reduction | 74.7 | 0.323 | 4th Reduction | 76.4 | 0.351 |
| 5th Reduction | 75.3 | 0.340 | 5th Reduction | 77.0 | 0.369 |
| Red Dog | 75.9 | 0.360 | Red Dog | 77.7 | 0.400 |
| Tail Shorts | 76.1 | 0.368 | Tail Shorts | 78.0 | 0.415 |
| Head Shorts | 82.7 | 0.598 | Head Shorts | 85.9 | 0.801 |
| Bran | 100.0 | 1.346 | Bran | 100.0 | 1.600 |

**Figure 9. Milling ash curves for two soft red winter wheat varieties from Arkansas for the US Wheat Associates, 2009 OVA.**



Mill stream analysis for cumulative ash and flour streams for 2009 OVA samples from Arkansas.

| USG 3665 | | | DK 9577 | | |
|---|---|---|---|---|---|
| Mill Stream | Cumulative Stream % | Cumulative ash % | Mill Stream | Cumulative Stream % | Cumulative ash % |
| Duster | 5.2 | 0.261 | Duster | 5.5 | 0.260 |
| 2nd Break | 20.1 | 0.262 | 1st Reduction | 15.3 | 0.262 |
| 2nd Reduction | 35.0 | 0.263 | 2nd Reduction | 37.9 | 0.273 |
| 1st Reduction | 43.6 | 0.263 | 2nd Break | 52.4 | 0.276 |
| 1st Break | 53.6 | 0.266 | Grader | 57.0 | 0.277 |
| Grader | 58.3 | 0.268 | 1st Break | 66.4 | 0.280 |
| 3rd Break | 61.7 | 0.281 | 3rd Break | 69.6 | 0.291 |
| 3rd Reduction | 69.9 | 0.309 | 3rd Reduction | 74.1 | 0.314 |
| 4th Reduction | 72.0 | 0.329 | 4th Reduction | 75.0 | 0.324 |
| 5th Reduction | 73.3 | 0.361 | 5th Reduction | 75.7 | 0.341 |
| Tail Shorts | 73.7 | 0.378 | Red Dog | 76.4 | 0.370 |
| Red Dog | 74.9 | 0.428 | Tail Shorts | 76.7 | 0.382 |
| Head Shorts | 83.7 | 0.782 | Head Shorts | 84.3 | 0.698 |
| Bran | 100.0 | 1.457 | Bran | 100.0 | 1.471 |

**Table 39. USDA ARS Soft Wheat Quality Laboratory wheat analytical values and milling data for ten soft red winter varieties, U.S. Wheat Associates, 2009 Overseas Varietal Analysis.**

| | | | | Single Kernel Characterization System | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Sample no. | Variety | Wheat protein† | Test weight | hardness | Kernel diameter | Kernel weight | Wheat moisture | Falling number | Grain alpha amylase |
| | | (%) | (lb $bu^{-1}$) | (score) | (mm) | (mg) | (%) | (sec) | (CU) |
| 901 | Dominion | 9.6 | 63.8 | 27.6 | 2.52 | 31.3 | 12.8 | 323 | 0.114 |
| 902 | Shirley | 9.2 | 62.1 | -1.6 | 2.50 | 35.2 | 12.5 | 383 | 0.097 |
| 903 | USG 3555 | 9.9 | 60.5 | 0.6 | 2.56 | 34.1 | 11.8 | 342 | 0.144 |
| 904 | Branson | 10.3 | 61.4 | -2.8 | 2.49 | 34.1 | 12.9 | 305 | 0.070 |
| 905 | Coker 9553 | 12.0 | 59.2 | 7.6 | 2.63 | 35.8 | 12.3 | 395 | 0.072 |
| 906 | USG 3665 | 10.7 | 65.5 | 11.9 | 2.35 | 27.4 | 12.8 | 373 | 0.076 |
| 907 | Coker 9804 | 11.7 | 63.7 | 31.0 | 2.53 | 31.4 | 12.8 | 368 | 0.054 |
| 908 | DK 9577 | 10.1 | 62.7 | 15.1 | 2.32 | 26.0 | 12.7 | 447 | 0.066 |
| 909 | Pioneer 26R15 | 9.8 | 65.3 | 21.9 | 2.37 | 32.7 | 12.7 | 380 | 0.058 |
| 910 | Pioneer 26R22 | 10.6 | 61.8 | 3.4 | 2.59 | 33.8 | 12.4 | 327 | 0.070 |

† Values expressed on a 12% moisture basis.

**Table 40. USDA ARS Soft Wheat Quality Laboratory flour analytical data for ten soft red winter varieties, U.S. Wheat Associates, 2009 Overseas Varietal Analysis.**

| | | | | Miag Multomat | | | Alveograph measures | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Sample no. | Variety | Flour protein† | Flour ash† | Break flour yield | Straight grade yield | Damaged starch | P | L | W | P/L |
| | | (%) | (%) | (%) | (%) | (%) | (mm) | (mm) | ($x10^{-4}$J) | |
| 901 | Dominion | 8.00 | 0.390 | 24.36 | 74.05 | 3.50 | 45 | 106 | 144 | 0.42 |
| 902 | Shirley | 7.25 | 0.402 | 30.84 | 74.84 | 3.24 | 28 | 75 | 48 | 0.37 |
| 903 | USG 3555 | 8.16 | 0.449 | 30.66 | 68.26 | 2.75 | 38 | 156 | 138 | 0.24 |
| 904 | Branson | 8.55 | 0.409 | 33.40 | 73.49 | 1.02 | 38 | 157 | 171 | 0.24 |
| 905 | Coker 9553 | 10.02 | 0.367 | 29.40 | 66.66 | 2.68 | 50 | 200 | 206 | 0.25 |
| 906 | USG 3665 | 9.08 | 0.377 | 32.81 | 73.00 | 2.63 | 32 | 180 | 118 | 0.18 |
| 907 | Coker 9804 | 10.13 | 0.382 | 23.82 | 74.56 | 3.77 | 57 | 161 | 243 | 0.35 |
| 908 | DK 9577 | 8.50 | 0.379 | 31.37 | 75.06 | 3.25 | 30 | 159 | 100 | 0.19 |
| 909 | Pioneer 26R15 | 8.49 | 0.407 | 25.82 | 74.89 | 2.46 | 44 | 110 | 162 | 0.40 |
| 910 | Pioneer 26R22 | 8.78 | 0.353 | 29.56 | 76.79 | 1.52 | 27 | 157 | 82 | 0.17 |

† Values expressed on a 14% moisture basis.

**Table 41. USDA ARS Soft Wheat Quality Laboratory solvent retention capacity and cookie baking data for ten soft red winter varieties, U.S. Wheat Associates, 2009 Overseas Varietal Analysis.**

| | | Solvent Retention Capacity | | | | Wire-Cut Cookies | | | Sugar Snap Cookie | |
|---|---|---|---|---|---|---|---|---|---|---|
| Sample No. | Variety | Water | Sod. Carbonate | Sucrose | Lactic Acid | Diameter† | Stack ht. † | Force | Diameter | Top grain |
| | | % | % | % | % | cm | cm | g | cm | score |
| 901 | Dominion | 57.2 | 75.0 | 94.5 | 109.0 | 15.23 | 2.29 | 1076 | 17.94 | 7.0 |
| 902 | Shirley | 55.7 | 76.5 | 87.5 | 81.2 | 15.56 | 2.28 | 964 | 18.77 | 6.5 |
| 903 | USG 3555 | 56.1 | 82.5 | 103.2 | 104.5 | 15.60 | 2.25 | 994 | 18.28 | 6.0 |
| 904 | Branson | 52.8 | 71.8 | 90.1 | 119.1 | 16.18 | 2.02 | 889 | 18.60 | 6.5 |
| 905 | Coker 9553 | 55.5 | 75.8 | 98.5 | 121.3 | 15.60 | 2.22 | 1092 | 17.94 | 5.0 |
| 906 | USG 3665 | 55.0 | 74.3 | 88.8 | 103.8 | 16.00 | 2.10 | 892 | 18.49 | 7.0 |
| 907 | Coker 9804 | 57.2 | 70.2 | 92.7 | 109.5 | 14.89 | 2.22 | 1086 | 17.26 | 5.0 |
| 908 | DK 9577 | 54.6 | 72.1 | 88.6 | 97.2 | 15.99 | 2.11 | 820 | 18.43 | 5.5 |
| 909 | Pioneer 26R15 | 53.2 | 67.2 | 89.2 | 111.6 | 15.88 | 2.12 | 1039 | 18.51 | 7.0 |
| 910 | Pioneer 26R22 | 53.1 | 70.9 | 92.0 | 93.0 | 15.99 | 2.00 | 937 | 18.77 | 7.0 |

† Sum value of two cookies averaged over two bakes.

**Table 42. USDA ARS Soft Wheat Quality Laboratory Rapid Visco-Analyzer flour pasting values for ten soft red winter varieties, U.S. Wheat Associates, 2009 Overseas Varietal Analysis.**

| Sample number | Variety | Peak height (cP) | First trough (cP) | Break-down (cP) | Final visc. (cP) | Setback (cP) | Peak time (min) | Pasting temp. (C˚) |
|---|---|---|---|---|---|---|---|---|
| 901 | Dominion | 2914 | 1627 | 1287 | 3157 | 1531 | 5.97 | 85.93 |
| 902 | Shirley | 2737 | 1785 | 952 | 3534 | 1749 | 5.97 | 83.93 |
| 903 | USG 3555 | 2457 | 1341 | 1117 | 2797 | 1457 | 5.87 | 85.15 |
| 904 | Branson | 2744 | 1308 | 1436 | 2610 | 1302 | 5.87 | 81.53 |
| 905 | Coker 9553 | 3006 | 1884 | 1123 | 3462 | 1579 | 6.10 | 84.35 |
| 906 | USG 3665 | 2985 | 1629 | 1357 | 3155 | 1526 | 5.97 | 83.98 |
| 907 | Coker 9804 | 3190 | 1866 | 1324 | 2490 | 624 | 5.90 | 66.95 |
| 908 | DK 9577 | 3248 | 2053 | 1196 | 3690 | 1638 | 6.17 | 83.10 |
| 909 | Pioneer 26R15 | 2984 | 1618 | 1366 | 2928 | 1310 | 5.97 | 83.53 |
| 910 | Pioneer 26R22 | 3009 | 1592 | 1417 | 2909 | 1317 | 6.04 | 77.45 |

**Table 43. Average values for flour and rheology measures from 2009 U.S. Wheat Associates, Overseas Varietal Analysis.**

| | | Flour protein[2] | Flour ash[2] | Wet gluten[3] | Gluten index[4] | Falling no.[5] | Alveograph[1] P | Alveograph[1] L | Alveograph[1] W | Alveograph[1] P/L | Farinograph[6] Arrival time | Farinograph[6] Stability | Farinograph[6] Water absorp. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | % | % | % | | sec | mm | mm | ($10^{-4}$ joules) | | min | min | % |
| Dominion | 901 | 8.3 | 0.391 | 21.1 | 87.5 | 344.0 | 46.3 | 85.0 | 124.0 | 0.59 | 0.98 | 1.73 | 52.5 |
| Shirley | 902 | 7.4 | 0.413 | 17.7 | 64.2 | 400.0 | 40.9 | 56.2 | 56.2 | 1.27 | 0.89 | 1.36 | 52.2 |
| USG 3555 | 903 | 8.2 | 0.444 | 20.0 | 93.4 | 348.4 | 37.9 | 116.0 | 118.4 | 0.45 | 1.22 | 4.44 | 51.0 |
| Branson | 904 | 8.6 | 0.447 | 21.1 | 86.2 | 333.8 | 40.0 | 102.8 | 132.2 | 0.50 | 1.11 | 4.76 | 50.3 |
| Coker 9553 | 905 | 10.0 | 0.372 | 28.1 | 75.7 | 385.2 | 50.4 | 128.8 | 166.4 | 0.49 | 2.72 | 7.83 | 54.5 |
| USG 3665 | 906 | 9.1 | 0.391 | 25.5 | 66.8 | 388.4 | 37.2 | 125.2 | 117.0 | 0.44 | 1.01 | 3.17 | 52.5 |
| Coker 9804 | 907 | 10.1 | 0.372 | 28.6 | 82.5 | 387.6 | 57.0 | 124.2 | 206.4 | 0.49 | 2.89 | 10.52 | 55.0 |
| DK 9577 | 908 | 8.7 | 0.373 | 24.0 | 67.4 | 427.2 | 34.2 | 121.8 | 108.4 | 0.49 | 0.92 | 2.89 | 51.8 |
| Pioneer 26R15 | 909 | 8.9 | 0.364 | 22.7 | 93.8 | 341.4 | 50.1 | 77.2 | 141.6 | 0.71 | 1.02 | 4.25 | 50.6 |
| Pioneer 26R22 | 910 | 8.9 | 0.400 | 25.3 | 37.9 | 335.2 | 32.3 | 106.2 | 88.2 | 0.47 | 0.94 | 2.51 | 51.4 |

1. Alveograph data from SWQL, Dominican Republic, Mexico, Peru, and UAE
2. Flour protein and ash averaged from SWQL, China III, China IV, Dominican Republic, Mexico, Peru, and UAE.
3. Wet gluten averaged from China III, China IV, Dominican Republic, Mexico, Peru, and UAE.
4. Gluten index averaged from China III, Dominican Republic, Mexico, Peru, and UAE.
5. Falling number averaged from SWQL, Dominican Republic, Mexico, Peru, and UAE.
6. Farinograph data averaged from China III, China IV, Dominican Republic, Mexico, Peru, and UAE.

# Genotyping for Quality Traits: 2009 Overseas Varietal Analysis

**Anne Sturbaum**

Genotyping was done at the Soft Wheat Quality Lab and the Regional Small Grains Genotyping Laboratory in Raliegh, N.C**.** for the 10 varieties Baldwin, Coker9553, DK9577, Jamestown, Malabar, Merl, Oakes, Renegade, Shirley and USG3555.

Amplification for high molecular weight glutenins at the *GluA1* locus, using the marker umn19, identified the *Ax2** genotype in Baldwin, Jamestown, Renegade and USG3555. Coker9553 was heterozygous. All other varieties had the *Ax1* genotypes as evaluated by Ax1/Ax2* markers (Liu S. C., 2008) (Ma W. Z., 2003).

Primers amplifying a 45 bp insertion specific to the Bx7 over-expressing allele were detected for two lines, Baldwin and Renegade. All other varieties contain the wild type allele at this locus (Guttieri, 2008).

Primers specific for GluD1, *Dx5* (Guttieri, 2008), generated a PCR product corresponding to the “5+10” genotype in Baldwin. DK9577, Malabar and Renegade were heterozygous at this locus. All other varieties produced amplification products specific for the “2+12” allele (Wan, 2005).

Allele-specific primers for γ-Gliadin identified all varieties with the *GliD1.1* allele (Zhang W. G., 2004).

The 1B/1R rye translocation was detected in varieties Baldwin, Shirley and USG3555, as they produced an amplification product with primers specific for rye ω-secalin using the Scm9 marker pair (Saal, 1999) (de Froidmond, 1998).

All genotypes in this set produced the anticipated banding patterns for normal amylose genotypes (non-waxy) at both the A and B GBSS loci (Nakamura, 2002).

Alleles of the *Vp1B* gene (Viviparous-1), assayed using primers Vp1B3, are associated with tolerance to preharvest sprouting. Coker9553, DK9577, Jamestown, Malabar and Oakes produced a 569 bp product indicating tolerance to PHS. All other varieties amplified the larger product (652 bp), indicating probable susceptibility to PHS (Yang, 2007).

Dwarfing genes were tested using markers specific for *Rht1, Rht2* and *Rht8*. Malabar, Renegade and Shirley contain the allele *Rht1*, all others were scored as *Rht2*, none had the *Rht8* allele (Zhang X. Y., 2006).

The semi-dominant *Photperiod-D1a* (*Ppd-D1a*) allele confers photoperiod insensitivity in wheat, allowing early flowering. All the varieties tested produced a product indicating the favorable photoperiod allele except for Baldwin and Malabar (Beales, 2007).

The presence of a stem rust resistance gene, *Sr36*, was tested using marker wmc477. A 185 base pair amplification product indicates the presence of a translocation from *Triticum. timopheevi* conferring resistance to the stem rust pathogen. Oakes, Shirley and USG3555 amplified the resistance allele while the other varieties amplified the wild type product at this locus (Tsilo, 2008).

Markers associated with two Fusarium Head Blight resistance QTL, located on chromosomes 3BS (Umn10) and 5A (gwm304 and wmc705), were tested against this set of varieties. The only line to carry favorable FHB resistance alleles was Malabar for the 5A Ernie QTL (Liu S. P., 2008) (McCartney, 2007).

See Genotyping Bibliography in the Materials and Methods Section.

# Fiber Variation in Whole-Grain Soft Wheat Flour within the United States

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## INTRODUCTION

The USDA National Nutrient Database for Standard Reference is used as a standard reference for labeling and dietary formulation. The profile for whole grain wheat flour (NDB No. 20080) is largely based on hard wheat flour samples and differs from the expected profile for soft wheat whole grain flour samples for important nutrients, most notably total grain protein concentration. Also, the fiber content of the flour in the database is *imputed*, that is derived, but not measured directly.

The purpose of this study was to measure the fiber content of whole grain wheat flour prepared from soft wheat using the Integrated Total Dietary Fiber method (AACCI Method 32-45.01/AOAC Method 2009.01) and assess the range in variation.

## MATERIALS AND METHODS

Study I: Commercial whole grain pastry flour and graham flour were obtained either from a local health food store or from commercial graham flour mills.

Study II: Grain of two cultivars was produced in Ohio State University trials at two Ohio locations in 2007, 2008, and 2009. Grain was milled on the Soft Wheat Quality Laboratory's Miag Multomat flour mill. Bran fractions were ground using a Quadro CoMill and combined with white flour to the original proportions.

Study III: Grain was obtained from commercial cooperators in 13 U.S. growing regions. Whole grain flour was prepared from this grain as described above. Twelve of the 22 flour samples were characterized in duplicate; two were characterized in triplicate. The remaining 8 were characterized once.

Fiber Analyses: Covance Laboratories, Inc., Nutritional Chemistry Group provided the analyses of dietary fiber as per AOAC 2009.01.

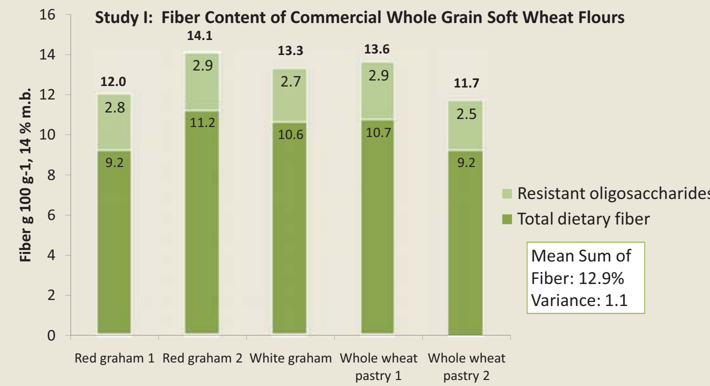
Statistical Analyses: Fiber concentrations were adjusted to a 14% moisture basis to standardize among samples of different moisture content. Data were analyzed using analyses of variance in SAS.



## Study III: Mean fiber in whole grain flour prepared from grain from each draw region (14% m.b.).

| State/Market class | N | Total dietary fiber ($g\ 100\ g^{-1}$) | Sum of res. oligosacch. ($g\ 100\ g^{-1}$) | Sum of fiber fractions ($g\ 100\ g^{-1}$) |
|---|---|---|---|---|
| ID SWW | 2 | 10.21 | 2.63 | 12.76 |
| Western OR SWW | 2 | 10.18 | 2.81 | 12.91 |
| Eastern OR SWW | 2 | 9.87 | 2.89 | 12.98 |
| MI SWW | 2 | 9.87 | 2.42 | 12.40 |
| IL SRW | 2 | 10.44 | 2.31 | 12.65 |
| IN SRW | 1 | 10.60 | 2.20 | 13.06 |
| OH SRW | 2 | 10.61 | 2.45 | 13.18 |
| ONT SRW | 2 | 10.20 | 2.64 | 12.74 |
| MO SRW | 2 | 10.67 | 2.87 | 13.43 |
| AR SRW | 1 | 9.72 | 2.22 | 12.19 |
| GA SRW | 2 | 10.35 | 2.07 | 12.34 |
| SC SRW | 1 | 9.90 | 2.20 | 12.36 |
| VA SRW | 1 | 9.48 | 2.11 | 11.78 |

Mean Sum of Fiber: 12.7%
Variance: 0.2




## Study II: Analysis of variance and means by year, location, and genotype.

| | df | Mean square term | | |
|---|---|---|---|---|
| | | Total dietary fiber | Sum of res. oligosacch. | Sum of fiber fractions |
| Year | 2 | 1.49** | 0.74* | 4.12** |
| Location | 1 | 0.55** | 0.09 | 0.21* |
| Loc w/in Yr | 2 | 0.00 | 0.01 | 0.01 |
| Genotype | 1 | 3.15** | 0.02 | 3.58* |
| Error (Residual) | 5 | 0.19 | 0.10 | 0.39 |
| | | Fiber concentration $g\ 100\ g^{-1}$ (14% m.b.) | | |
| 2007 | | 10.35 | 2.50 | 12.85 |
| 2008 | | 10.46 | 2.45 | 12.95 |
| 2009 | | 11.45 | 3.22 | 14.65 |
| *Std. Error* | | *0.22* | *0.16* | *0.31* |
| | | | | |
| Northwest Branch | | 10.97 | 2.64 | 13.62 |
| Wooster | | 10.54 | 2.80 | 13.35 |
| *Std. Error* | | *0.18* | *0.13* | *0.25* |
| | | | | |
| Coral | | 10.24 | 2.68 | 12.94 |
| Hopewell | | 11.26 | 2.76 | 14.03 |
| *Std. Error* | | *0.18* | *0.13* | *0.25* |

The "McCleary method", also called the CODEX or 'All-in-One' method, is expected to become the benchmark method for dietary fiber. This study addresses the impact of using this method on the stated nutrient value of whole grain soft wheat flour. This is the first systematic survey of the US soft wheat crop for whole grain flour fiber content.

Acknowledgements: Research was supported by Kraft Foods, Kellogg Co., General Mills, the USDA-ARS Mid-West Area and the Ohio State University.

# Distribution of Non-Starch Polysaccharides in Soft Wheat Pilot Millstreams

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**Abstract.** The general objective of commercial soft wheat milling for low water absorption flour is to optimize flour extraction while minimizing starch damage and arabinoxylan (AX) and protein concentration.

Previous millstream analyses have used mills optimized for milling hard endosperm wheat for bread applications and have analyzed grain samples of either unspecified or identifiably hard endosperm. Yet the fracture properties of soft endosperm wheat kernels profoundly influence flow through the flour mill. Because of the different milling characteristics of soft wheat, industrial mills typically are optimized for this task.

A cross-section of seven eastern U.S. soft winter wheat genotypes were milled on a Miag Multomat flour mill flowed for soft wheat milling. Flour yield, ash, protein concentration, and water-extractable (WE-) non-starch polysaccharide concentration were measured on all ten streams.

**Figure 1.** Flow diagram of the Miag Multomat mill at the USDA Soft Wheat Quality Laboratory.

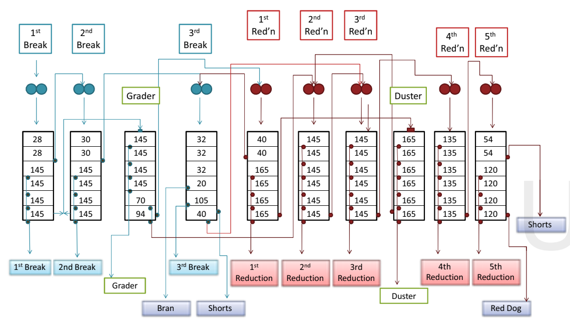



**Table 1.** Flour stream characteristics from the Miag Multomat mill, sorted by flour ash concentration. Mean of seven soft wheat genotypes.

| Stream | Ash | Recov. | WE-Xylose (rank) | WE-Galactose (rank) | WE-Glucose (rank) |
|---|---|---|---|---|---|
| | (%) | (%) | mg g-1 | mg g-1 | mg g-1 |
| 1st Red'n | 0.298 | 9.0 | 1.56 (1) | 0.82 (1) | 10.4 (5) |
| Duster | 0.308 | 5.9 | 2.33 (5) | 1.24 (6) | 9.5 (1) |
| 2nd Red'n | 0.321 | 20.4 | 2.69 (8) | 1.16 (5) | 10.1 (3) |
| 2nd Break | 0.336 | 12.2 | 1.91 (2) | 0.95 (2) | 10.5 (6) |
| Grader | 0.346 | 6.1 | 2.35 (6) | 0.98 (3) | 10.1 (2) |
| 1st Break | 0.357 | 7.6 | 1.91 (3) | 1.12 (4) | 10.2 (4) |
| 3rd Break | 0.510 | 3.3 | 2.15 (4) | 1.48 (7) | 15.1 (7) |
| 3rd Red'n | 0.549 | 5.7 | 2.59 (7) | 1.80 (8) | 16.0 (8) |
| 4th Red'n | 0.983 | 2.9 | 3.72 (9) | 3.34 (9) | 24.0 (9) |
| 5th Red'n | 1.567 | 0.6 | 4.37 (10) | 5.67 (10) | 37.0 (10) |

**Methods.** Grain was tempered to 14% moisture and milled on the Miag Multomat mill (Figure 1). Flour ash was analyzed by AACC 08-01 Aqueous phases from 1 g water SRC of millstreams were hydrolyzed in 2 N trifluoroacetic acid for 1 h at 105 C, derivatized to alditol acetates, and analyzed by gas chromatography as described previously (Guttieri et al. 2008).

**Figure 2.** Flour recovery and flour ash in the reduction streams from the Miag Multomat mill of seven soft wheat genotypes. Both recovery and ash fit exponential functions for all genotypes.

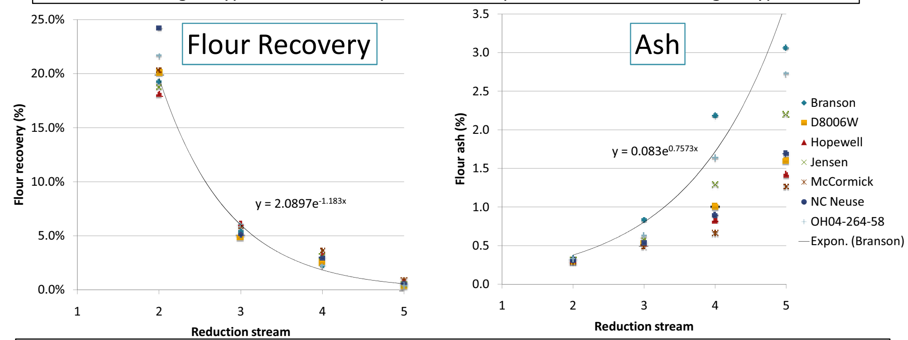



**Figure 3.** Exponential increase in water-extractable polymers of glucose and linear increase in flour protein in reduction streams with OH04-264-58 as an outlier genotype.

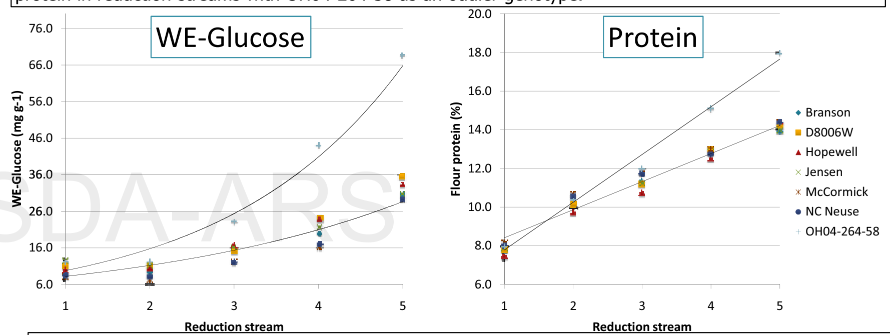
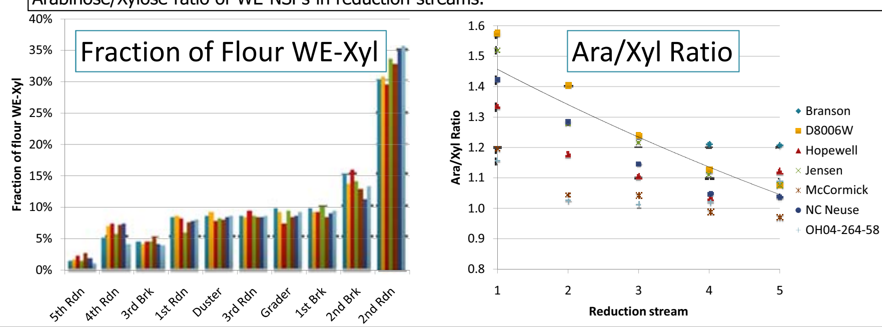



**Figure 4.** Fractional contribution of each flour stream to total WE-Xylose in straight grade flour, and Arabinose/Xylose ratio of WE-NSPs in reduction streams.




**Results.** Flour recovery declined exponentially through the reduction rolls, and flour ash increased exponentially, but varied among genotypes (Fig 2). WE-Glucose also increased exponentially through the reduction streams, indicating that this is an effect of roll action on starch granules. Flour protein increased linearly through reduction streams.

The combined effects of moderate WE-Xyl and high recovery in the 2nd reduction stream led to its predominant contribution to WE-Xyl in straight grade flour. Moreover, Ara/Xyl structure differences among genotypes are apparent in the 2nd red'n stream (Fig. 4). These two factors explain the previously observed predictive ability of micromilling methods for long flow milling.

These data also suggest that discrimination among genotypes in micromilling with sucrose SRC testing might be improved by focusing on the reduction flour fraction.

Acknowledgements: Research was supported by Kraft Foods, The Ohio State University, and the USDA-ARS Mid-West Area.

# Pre-harvest Sprouting of Wheat, Alpha-Amylase Enzyme, and Falling Number

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Soft Wheat Quality Lab website: http://www.ars.usda.gov/main/site_main.htm?modecode=36-07-05-00

Pre-harvest sprouting (PHS) in wheat occurs when the crop is exposed to rain after a field reaches maturity. Sprouting grain produces **α-amylase**, an enzyme that rapidly breaks starch into simple sugars. Grain values decline rapidly as the level of alpha amylase increases, and grain elevators pay lower prices for sprouted grain since limited options exist for resale. In cases of severe sprouting, grain is acceptable for animal feed, only. We evaluated trials in Maryland for three years measuring PHS with Falling Number and Alpha Amylase assays in collaboration with the University of Maryland. The main conclusions were:

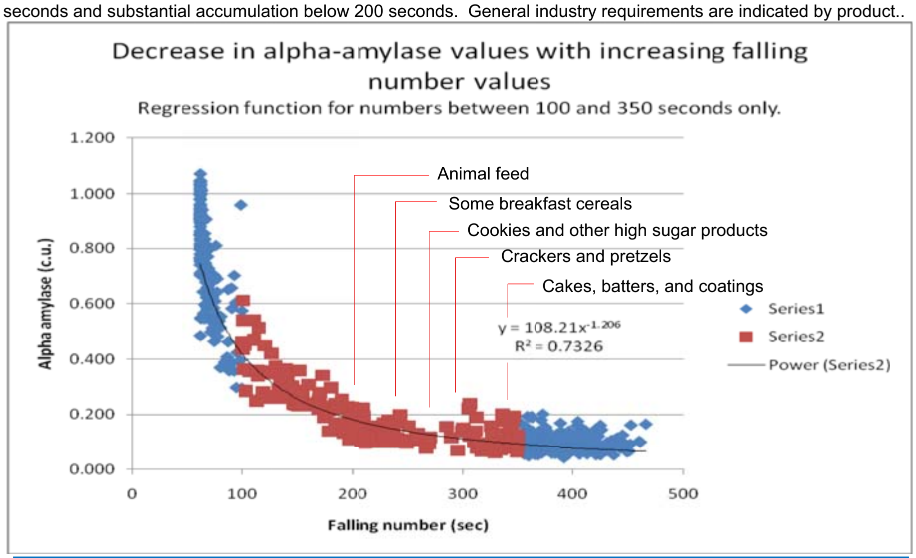
1) Cultivars differ greatly in their sensitivity to moisture/rainfall after maturity, with Coker 9553, McCormick, SS 8302, and SS 8404 being the least prone to pre-harvest sprouting as measured by Hagburg Falling Number Test.
2) α-amylase enzyme activity, measured indirectly through falling number, often does not increase immediately in all cultivars and frequently is not significant until falling number values are significantly less than 300 seconds.

Cultivar information is directly useful for grower planting decisions. Data is available on the USDA-ARS Soft Wheat Quality web site.
Buyers should be encouraged to purchase moderate falling number grain for higher-end use since α-amylase levels are undetected at 240 sec to 350 sec FN.

## What is Sprouted Grain Good For?

As falling number test values decrease below 350 seconds, the amount of the starch damaging enzyme, alpha amylase, increases. The fewer the uses for the grain, the lesser is its value, and the lower its price. Depending on formulation and equipment, food manufactures can use different levels of partially sprouted grain. Below is a general guide to the uses of partially sprouted grain.

Figure 1. Alpha-amylase increases as Falling Number values decrease, with minor accumulation below 350 seconds and substantial accumulation below 200 seconds. General industry requirements are indicated by product..




## PRE-HARVEST SPROUTING

Pre-harvest sprouting occurs when the wheat crop is exposed to extended periods of rain or heavy dews.

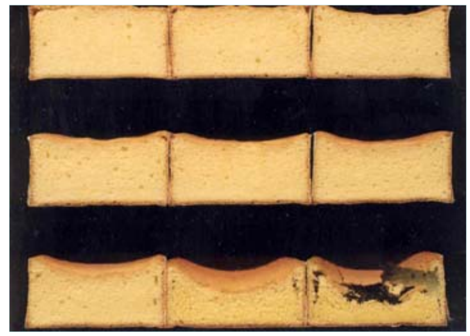
The first stage of sprouting: alpha-amylase enzyme is synthesized and starch in the seed is broken down to make sugar for the new seedling to grow.

The longer sprouting continues the more damage occurs to the starch and the less usable the grain is for human consumption.

The last stage of sprouting is the visual emergence of a shoot breaking the seed coat.
Much of the damage to grain quality has already occurred prior to visual sprouting.

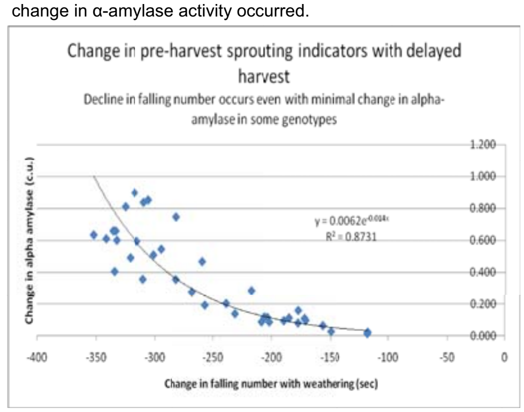
Harvesting early at high moisture (~20%) then drying the grain can reduce exposure to pre-harvest sprouting. Some cultivars are more resistant to pre-harvest sprouting than others.

## Cake Texture is Ruined by Pre-harvest Sprouting



In the picture above, cakes made with different flour with increasing levels of pre-harvest sprouting. Flour from un-sprouted grain is in the upper left and the most sprouted sample in the lower right. (Image from USDA-ARS Pullman)

Figure 2. An initial reduction in Falling Number was independent of α-amylase activity. Comparing early harvested to late harvested grain, we observed as much as 100 to 150 seconds reduction in Falling Number before any measureable change in α-amylase activity occurred.




## The Falling Number Test for Measuring Pre-harvest Sprouting (AACC Method 56-81B).

Automated Shaker


Falling Number Tester


Plungers falling (sprouted on left)

Samples of ground grain or flour are suspended in water using an automated shaker.

Tubes with the suspended water and ground grain are heated in the falling number tester until the starch in the sample gelatinizes (becomes like a thick gravy).

Plungers on the tester are released and fall through the thickened slurry. Sprouted samples have degraded starch and very thin gravy mixtures. The plunger falls quickly in sprouted samples. The time to reach the bottom of the tube is measured in seconds and determines the amount of sprouting.

<u>Test accuracy requires uniform sample grinding (no coffee grinders), uniform shaking, and clean equipment.</u>

Visual sprouting symptoms are generally correlated to falling number. Yet significant loss of quality can occur before visual sprouting occurs – This is the reason that most mills and flour purchasers require direct measures of starch quality such as the falling number test.

# Development and Distribution of Male-Sterile Facilitated Recurrent Selection Populations

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J. Costa, C. Griffey, S. Harrison, J. Johnson, and P. Murphy

## Introduction

Recurrent selection is a breeding procedure with the objective of increasing the frequency of desirable alleles for one or more traits while maintaining a high level of variability in the population. Intermating among selected parents each generation allows recombination to occur thus combining genes from different sources. Male sterility in a self-pollinated species provides a mechanism to easily produce many crosses. Male-sterile plants to not produce viable pollen. Thus, any seed from a sterile plant must be a hybrid via pollen from a male-fertile plant. In contrast, hand pollination requires laborious manual emasculation and pollination.
Male-sterile recurrent selection in wheat derives its power from recombination of sources of genetic variation for a specific trait and intensity of selection due to large population size that results from many crosses. Progress from selection when recombining genetic sources of FHB resistance is directly related to the amount of genetic variation for the trait in the population and the identification of parents with a high level of expression of the desired trait.
The dominant male-sterile gene was utilized rather than the recessive gene because the progenies of the male-sterile plants always segregate 1:1 for sterility and a generation of selfing is not required to obtain true-breeding fertile genotypes.
Our objective is to create four populations with FHB resistance adapted to different regions of the eastern U.S.

## Methods and Materials

The male- sterile populations derive from the Idaho Intensive Management Male-Sterile population (PI 573190). They have been developed in Wooster, OH since 2006, using elite soft red winter and soft white winter wheat varieties as pollinators. Some were included as sources of FHB resistance and others as sources of adaptation and genes for high yield potential. We used the following procedure:
- A mixture of pollinators are planted in rows that alternate with the male-sterile plants (Figure 1). Seed from the sterile heads are planted, and their sterile offspring are tagged for harvest to repeat the process. Sterile plants are selected; those highly susceptible to FHB are discarded. Fertile offspring can be selected for future breeding (process outlined in Figure 4).
- In 2009, different generations of the selected male-sterile populations were grown in the field at Wooster, OH. From this, four populations were developed in 2009-2010:
  1. The early maturity selections from the male-sterile population were planted with pollinator parents for a southern-mid-Atlantic soft red wheat population.
  2. Two-thirds of the seed from the mid-maturity selections from the male-sterile population were planted with pollinator parents for an early Midwest soft red wheat population.
  3. One-third of the seed from mid-maturity selections from the male-sterile population and some from the late selections were planted with pollinator parents for a late Midwest soft red wheat population.
  4. Late maturity selections from the male-sterile population were planted with pollinator parents for a late soft winter wheat population, including white winter wheat genotypes.

-In summer 2010, sterile heads were identified . They were tagged at four different dates: May 20-22, May 24-26, May 28-30, and June 1 depending on maturity, using a different colored tag each day (Figure 2). Sterile heads that were very susceptible to *Fusarium graminearum* (Figure 3) were removed on June 14 (early Midwest and mid-Atl.) and June 17 (late Midwest and white). After being harvested and threshed, *Fusarium* damaged kernels were removed by aspiration.
-A bulk from each population will be distributed to cooperating breeding programs in Fall 2010.

## Pollinators

| Midwest Early | Midwest Late | Mid-Atlantic | White |
|---|---|---|---|
| IL02-18228 | Malabar | MILUS ARGE97-1048 | 20799-71 |
| IL00-8061 | OH05-200-74 | MILUS ARGE97- 1047 | NY94052-9340 |
| Pembroke | OH618 | MILUS ARGE97-1042 | NY93285-7110 |
| KY04C-2151-2 | Bromfield | Dominion | NY92237-1-SP-9173 |
| KY02C-2215-10 | 9951A1-6-3-94 | VA04W-90 | NY91028SP-9082 |
| KY02C-3004-02 | 07282A1-33 | VA04W-433 | NY99068-3251 |
| 04538A1-1-10-2-3 | MO 041020 | VA05W-251 | NY87048W-7388 |
| 053A1-2-5-3 | MO 081378 | Tribute | NY91017-8080 |
| MO 080104 | MO 050921 | Jamestown | JENSEN |
| MO 081652 | | MD08-22-16 | NY94052-6090 |
| MO 041687 | | MD08-15-4 | NY99045-3110 |
| | | MD01W233-06-1 | A99158WAB-1 |
| | | MD-C-07-027-H7 | Coral |
| | | | Aubrey |
| | | | E6003 |
| | | | E6012 |

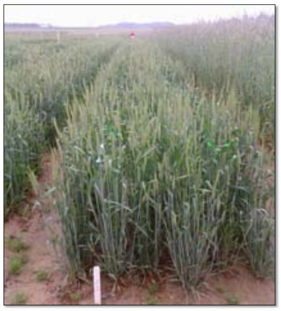


**Figure 1.** Example of the 6-row plots. Male-steriles are planted in rows 2 and 5, and a mixture of pollinators are planted in 1, 3, 4, and 6.

**Figure 2.** Sterile heads tagged for harvest. Plants were tagged on different days, using different colors, based on their maturity.

**Figure 3.** On left, a head more resistant to FHB . It initially became infected but the fungus did not spread throughout the head, as it did in the more susceptible head on the right.

## References

Sorrells, M.E. and S.E. Fritz. 1982. Application of a dominant male-sterile allele to the improvement of self-pollinated crops. Crop Sci. 22: 1033-1035.
Souza, E., J.M. Tyler, and K.M. O'Brien. Registration of Idaho Intensive Management Male Sterile Population, Cycle 0, winter wheat germplasm. 1994. Crop Sci. 34:1136-1137.

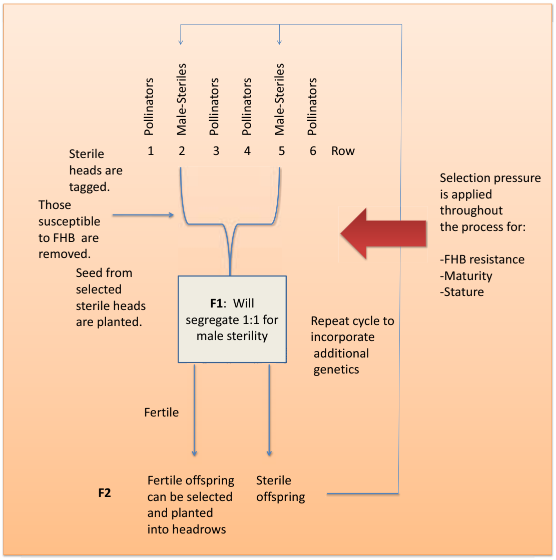



**Figure 4.** Male sterile plants are heterozygous for sterility ; fertile plants are homozygous for the recessive allele. They inter-mate and half of their progenies will be fertile, being homozygous recessive, and half will be sterile, having one dominant allele. Because sterile plants contribute one dominant and one recessive allele and must be pollinated by a homozygous fertile plant, sterility will always appear in a 1:1 ratio in the progenies.

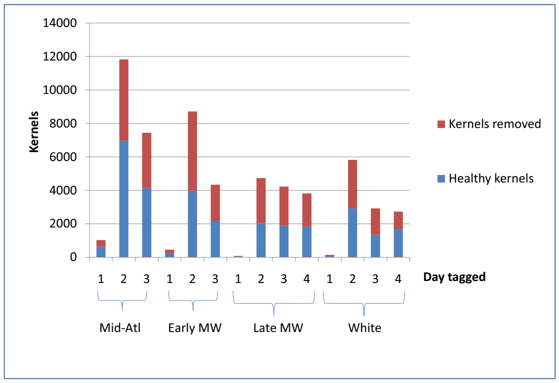



**Figure 5.** A comparison of *Fusarium* damaged kernels removed through aspiration, and those healthy kernels remaining to be distributed.

## Results

The effectiveness of this procedure is in part dependent upon the ability to discard material susceptible to FHB. In the field when removing susceptible sterile heads, the selection intensity ranged from an estimated 25-40% (Mid-Atl), 50-65% (Early MW), to 50% (Late MW and White). Nevertheless, the harvested seed still contained significant amounts of *Fusarium* damaged kernels. An average of 40-50% of kernels were removed by aspiration (Figure 5), or 30-40% by weight.
990 grams (approximately 30,000 kernels) of healthy seed from the male-sterile plants remain to be distributed. Making crosses with manual emasculation and pollination, requires two minutes to obtain one seed. Generating the same amount of seed by hand that was produced from the male-sterile plants would require more than 124 eight hour work days.

# Using Male-Sterile Facilitated Recurrent Selection Populations

J. Shoots and M. Guttieri

*Department of Horticulture and Crop Science, The Ohio State University OARDC, Wooster, OH*

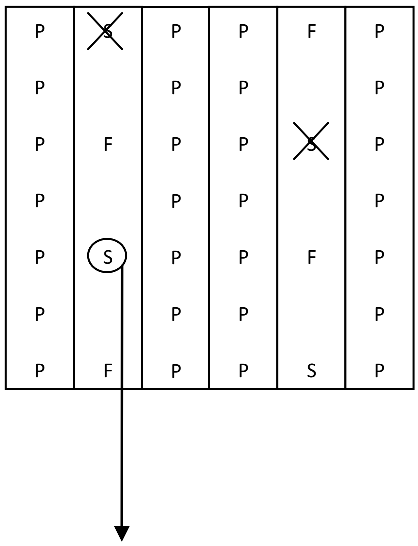
### *Planting*

Plant male-sterile seed at low density (1 seed/15 cm) in rows that alternate with a mixture of genotypes that will serve as pollinators, as shown below. Pollinators, including locally adapted sources of FHB resistance, high yield potential, and key biotic and abiotic stress resistances, should be planted in adjacent rows at high density.

| Pollinators | Male-Steriles | Pollinators | Pollinators | Male-Steriles | Pollinators |
|---|---|---|---|---|---|
| P | S | P | P | F | P |
| P | | P | P | | P |
| P | F | P | P | S | P |
| P | | P | P | | P |
| P | S | P | P | F | P |
| P | | P | P | | P |

### *Tagging*

Tag sterile spikes for harvest shortly after anthesis. At this point, sterile plants can be identified readily because the glumes flare open to receive pollen since the plant cannot produce its own pollen and the ovule swells. Below, the sterile head in the foreground is flared and lacks anthers, as compared to the fertile head in the background. We find laboratory tape placed below the spikes effective for labeling spikes in the field. Different colors of tape can be used to identify different tagging dates.

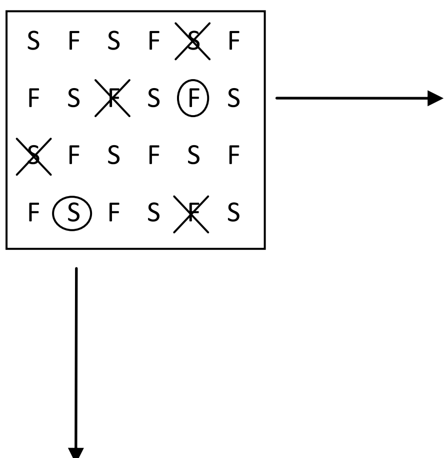



### *Selection*

Approximately 20 days after tagging remove those sterile plants highly susceptible to FHB. Progress is directly related to the breeder's ability to identify parents with a high level of expression of FHB resistance.

After harvest, the sterile seed can be further selected by removing the *Fusarium* damaged kernels by aspiration.

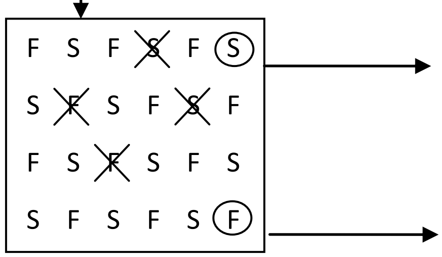
Plant the harvested seed from the sterile heads.
These F1 plants, the offspring of the sterile plants, will segregate 1:1 for sterility, as the dominant male-sterility gene was utilized. Male-sterile plants will be pollinated by fertile sib progeny.




Fertile genotypes can be selected and incorporated into the breeding program.

Sterile spikes can again be tagged and selection pressure can be applied. These spikes again can be harvested and planted.

Their offspring will again segregate 1:1 for sterility. After selection:




Sterile heads can be used to repeat the process with new pollinators to accumulate additional genetics.

Fertile genotypes can be selected and incorporated into the breeding program.

# The Plant Breeding and Genomics Community on eXtension: Putting Research into Practice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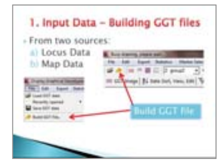
## ABSTRACT

Plant breeding can accelerate gains in the quality and output of agricultural crops by making use of genome sequence data. Understanding variation in genome sequence can be useful in crop improvement to the extent that it helps predict variation for agriculturally important traits. The **Plant Breeding and Genomics Community of Practice** on eXtension.org has formed, under the leadership of the SolCAP project, to help plant breeders translate basic research in genomics into practice. Our content emphasizes emerging sequence databases, genotyping techniques, and analytical methods. The community, consisting of public and private researchers and educators, has also developed videos and fact sheets for end users such as growers and processors. Content includes tutorials, case studies, reviews, and data sets in webinar, video, and text formats with short courses coming.


## TUTORIALS

- Software and data analysis
  - Software capabilities
  - Downloading & installing software
  - Importing data
  - Navigating software
- Data analysis tutorials focus on:
  - Performing appropriate analyses
  - Formatting data
  - Evaluating hypotheses
- Collaborative content





**www.eXtension.org/plant_breeding_genomics**

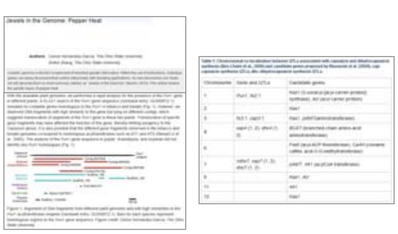
## GOAL

Put genomics research and tools into practice through plant breeding by:

- Presenting unbiased, science-based, and peer-reviewed content
- Sharing the most current, relevant, and accurate information available on techniques, procedures, and software
- Fostering collaboration among members of the plant breeding and genomics community


## REVIEWS

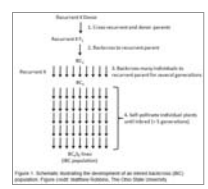
- Demonstrate the use of genomics research for crop improvement
- Value added information for practicing breeders (summary tables, markers, more)
- Focused on traits relevant to breeding





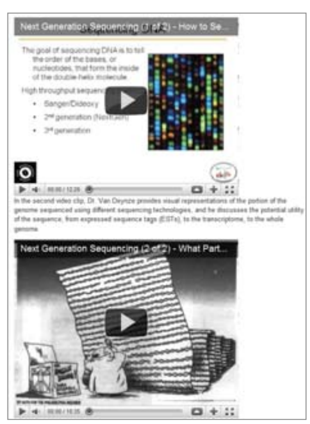
## CASE STUDIES

- Integrate theory, public resources, sample data, data analyses
- Examples include:
  - Developing populations
  - Accessing germplasm
  - Analyzing sample genotypic and phenotypic data



## WEBINARS & VIDEOS

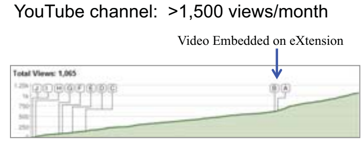
- Describe relevant techniques, software, and publicly available resources
- Provide supplementary data and files
- Current topics include:
  - Genome browsers
  - Genome sequencing
  - Sequence resources
  - High-throughput genotyping
  - Genotype analysis software
  - Bioinformatics





## CONTENT VIEWS

- Increase your plant breeding and genomics outreach impact through eXtension
- eXtension site: > 7,000 hits/month
- YouTube channel: >1,500 views/month




## GET INVOLVED

•200 colleagues from 55 institutions, join us!
•Contact: David Francis: francis.77@osu.edu or Heather Merk: merk.9@osu.edu
•Visit http//:pbgworks.org


## ACKNOWLEDGMENTS

Development of this poster was supported in part by the National Institute of Food and Agriculture (NIFA) Solanaceae Coordinated Agricultural Project, agreement 2009-85606-05673, administered by Michigan State University.